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THROUGH THE EYES OF THE EDITOR

Ruth Moulton discusses the psychologic considerations involved in the treatment of occlusion. She points out the tensions which may cause patients to respond in a satisfactory manner to the dentist's directions and to his work. The importance of "tensions" in temporomandibular joint disturbances is becoming increasingly apparent. Their importance in other prosthodontic problems is more obscure, but if the tensions are not recognized, their effects will add to the difficulties in many phases of complete and partial denture service. This may be observed in impression making as well as in recording jaw relations and in the adjustment period.

Dennie L. Briggs gives his views on the psychologic aspects of dental treatment in his discussion of the article by Dr. Ruth Moulton. He is in apparent agreement with the principles which Dr. Moulton outlines and suggests that dentists keep these principles in mind as they examine their own as well as their patients' attitudes and tensions.

Robert G. Schallhorn reports on his comparison of the arbitrary location of the axis of mandibular movement with the location determined by means of a kinematic facebow. This essay won the first prize in the essay contest for senior dental students which is sponsored by the American Denture Society. He is to be congratulated for his success.

Joseph S. Landa discusses the temporomandibular joint and its relation to occlusal disharmonies. He compares his observations made after several different approaches to the problem. He points out what he considers to be current misconceptions regarding the anatomy and function of the joint. He defines the masticatory mechanism as having two types of articulations, the "articulation" of the teeth and the articulation of the joints. He recognizes that these must be in harmony with each other, and suggests that the musculature is a dominating factor in this relationship. He correctly emphasizes the importance of the interocclusal rest space, and insists that this space must not be obliterated by restorations of any type which increase the occlusal vertical dimension.

Oliver C. Applegate discusses the factors which determine the choice between complete or partial dentures. His approach to the problem is sound, and it is apparently based upon a philosophy of conservative treatment. The conditions he considers are complex and interrelated, and it is obvious that they constitute a real challenge to the dental profession. Undoubtedly, there will be some who do not agree with all that he says, but when his procedures are used with the thoroughness that he has indicated, the chances that the correct decision will be arrived at are good. His concept and design of a "treatment denture" is worthy of further study. Since bone is the plastic tissue that it is, the use of these "treatment dentures" for stimulating the reorganization of the bone may prevent some of the settling of the subsequent restorations.

George W. Hindels classifies the stresses transmitted through distal extension partial

dentures to the abutment teeth, and suggests methods for controlling the unfavorable stresses. He shows that occlusal forces are ideally resisted if they are evenly applied throughout the denture bases and if they are applied in a vertical direction. He uses rigid reciprocal arms on clasps but he makes sure that the tooth surfaces against which they are placed are properly formed to accommodate them. He places more emphasis upon stability than retention and this seems to be a sound approach to the problem.

Charles V. Caldarone suggests a semiprecision retainer for partial dentures which does not have the esthetic disadvantages of clasp retainers. The technique is not difficult or complicated to use. However, there does not appear to be any way to adjust the retainer if it should become loose.

George H. Moulton discusses centric relation and the interocclusal distance in their relationship to dentitions and fixed partial dentures. He recognizes the importance of maintaining a space between the teeth when the mandible is in the physiologic rest position, and specifies reference points for the determination of the amount of this space. His definition of centric occlusion may be confusing since he designates both the relation of the teeth and the relation of the jaws in the same term. It seems simpler to designate the centric relation of the jaws and to prescribe the centric occlusion that will be in harmony with it. However, the basic idea he describes is correct. He points out the dangers involved in fitting casts together to determine the occlusion of restorations. If occlusal harmony is to be established, the occlusion must be coordinated within itself, and also coordinated with the neuromuscular system and temporomandibular joints. He believes that "test" splints are unnecessary if an adequate diagnosis is made.

Ralph S. Lloyd, Samuel Pruzansky, and J. Daniel Subtelny discuss the rehabilitation of cleft palate patients after they have had unsuccessful surgical treatment. These patients require the utmost of care and treatment since prosthetic restorations are the last resort. Plastic surgeons should not be criticized too much for their failures, because surgery does have its limitations. The prosthodontist, however, dare not fail after surgical failures because he is the only one who can help the patient. The authors list two objectives of prosthetic treatment. It seems that the importance of restoring occlusal function should have been emphasized more than it was. They suggest the use of cephalometrics and laminography for guidance in the construction of speech appliances. This certainly has merit. These techniques indicate a need for further study of the design and position of the obturators on speech appliances.

Gilbert P. Smith discusses the marginal fit of full cast shoulderless crowns, and describes procedures which are designed to make them more accurate in this critical area. The techniques he suggests should accomplish the desired results provided they are carried out accurately. His tests for the adaptation of the margins should prevent trouble subsequent to the cementation of crowns.

G. J. Perdigon and E. F. Van Eepoel describe a technique for minimizing the distortion produced by soldering procedures used in the construction of fixed restorations. The procedure is simple and apparently effective.

George T. Gregg describes his technique for making impressions for porcelain inlays without separating the teeth. He makes use of the rubber base impression materials and perforated trays which are made for each specific situation. The procedure might be adapted for other types of restorations.

Lester E. Myers discusses the advantages of gold foil restorations and describes his technique for making them. He combines mat and cohesive foil in these restorations and sees advantages in this combination. He emphasizes the importance of attention to detail for success in this work, and that applies to all dental operations.

Robert J. Clark and Ralph W. Phillips report their studies of the flow of fifteen dental impression materials. This information is valuable to the dentist who is concerned about the amount of pressure the impression is to exert against the soft tissues. They do not suggest a "correct" amount of flow, but they do indicate that the choice of material should be related to the technique and its objectives.

Harold H. Blank describes his techniques for using rubber impression materials for crowns, inlays, and fixed partial dentures.

These impression materials have certain advantages over other impression materials which make them suitable for the uses he suggests. The formation of an accurate tray is an essential part of these techniques.

Judson C. Hickey, Julian B. Woelfel, and Lloyd Rinear clearly demonstrate that the electrical fields set up in the muscles about the face overlap each other. They point out the fact that if this overlapping of electrical fields is not taken into consideration, electromyograms can be interpreted incorrectly. An incorrect interpretation of electromyograms certainly will lead to incorrect conclusions about the activity of the muscles about the face under various conditions. The discovery of this fundamental, and previously unreported or overlooked, phenomenon leads us to point out that every investigative method should be examined critically for possible errors. In this way, research can avoid going too far into blind alleys. It is important to note that the authors recognize the value of electromyography as an experimental method. Their warning is about incorrect interpretation of the data.

Hamilton B. G. Robinson reports the combined opinions of various investigators regarding the effects of different tooth-cutting methods on the pulps of teeth. Their findings indicate that when the newer methods are used intelligently, there is no significant damage to dental pulps. It is obvious that care is required in the use of any tooth-cutting method. Further research will establish the areas of potential damage so that any potential damage to pulps can be avoided.

—Carl O. Boucher

PSYCHOLOGIC CONSIDERATIONS IN THE TREATMENT OF OCCLUSION

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THERE HAS BEEN INCREASING evidence that the high pressure tensions of our culture are being translated into what is generally referred to as psychosomatic symptoms. It has long been known that body organs have been used to express emotion; but with the growth of our ability to make accurate scientific observations, the knowledge of the interrelationships between mind and body were often discredited because they were so hard to prove. It has been very hard to track down and document the exact physiologic mechanisms by means of which anxiety causes subjective pain or organ dysfunction. The age-old awareness of the use of body language is shown in such expressions as, "He gnashed his teeth in rage," or, "He clenched his jaw in determination." Not only is the mouth used to express rage, anger, and determination, as the above statements attest, but it is also used to express tender emotions and sexual desires. From childhood, the mouth is used both as a source of sensory pleasure, as in sucking, eating, or kissing, and also as a weapon of defense, as in biting, arguing, or attacking with words. The occlusion may be affected in a parallel way in two contradictory directions. Pathology of occlusion may occur through underuse of the jaw muscles or through overuse of them. Infantile dependent individuals often prefer soft, childish foods long past the age when this would be normal. They may refuse to chew hard food to such an advanced age that the jaw fails to develop properly, because normal muscle pull is necessary to its growth. Thus infantile eating patterns may play a role in causing malocclusion.[1] Often adolescents or adults approach the dentist with a "mouthless" facial expression of apathy, an open, drooping mouth, expressing a passive expectation of being taken care of. This type of person is more likely to have multiple subluxations of the jaw muscles because of their inadequate use and lack of muscle tone.

On the other hand, jaw muscles may be overused in individuals with the habit of bruxism, where grinding and clenching of the teeth become so habitual as a release of tension that ultimately severe pain results. Bruxism tends to be a reflexion of anxiety or rage and occurs most often in the kind of person who either experiences disproportionate anger or who does not know how to express

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rage effectively. Attempts to overcontrol anger and hold it in lead to clenching of the teeth. This type of person is likely to have a set, determined, or hostile facial expression, quite different from that of the first type described.

Thus the use of the mouth in expressing emotion is readily acceptable to most people. However, it has been hard to bridge the gap between the voluntary use of the body, such as clenching one's teeth in rage, and the involuntary consequences of such a so-called habit. The habit seems to take hold, becomes self-perpetuating, and has far-reaching effects on the body that were not anticipated or desired. Continued clenching of jaw muscles tends to lead to muscle spasm and resulting pain. This establishes a vicious circle because the pain attracts undue attention of the individual to his jaw muscles, and his tension is released through further clenching, which causes further pain. Of course muscles are accustomed to almost continuous action, but normally reciprocal innervation provides opportunity for intermittent relaxation, whereas in the tense, anxious individual, the constant use of muscles is unphysiologic.

RESEARCH ON TEMPOROMANDIBULAR JOINT PATIENTS

In a study of thirty-five cases of temporomandibular joint pain, patients who showed no structural pathology after thorough dental and medical study were then referred for a psychiatric consultation of one to one-and-one-half hours.[2] The most dramatic discovery was the predominance of chronic, long-standing bruxism as the most frequent common denominator in producing pain and spasm. At least half of the patients were aware of this habit, whereas others only became aware of it after questioning. The bruxism seems to have been more severe shortly before the onset of symptoms. The patients had often reached the climax of some life dilemma, which made them extremely anxious and enraged, but in their efforts to hold back their rage, they would find themselves grinding much more violently and for longer periods than they had done previously. This would finally lead to such severe pain and spasm that they were often unable to open their mouths wide enough on arising to eat an adequate breakfast.

The other half of this group dated their pain to some experience where they suffered excessive trauma in the dental region. There were many instances of prolonged extractions or multiple extractions, sometimes with poor anesthesia. The patient often was very poorly prepared by the dentist to accept the difficult treatment necessary, so that it came as a psychological shock. Often too much work was done at once. In other instances, there had been extensive efforts at occlusal rehabilitation. Some minor abnormality of the occlusion was noticed, and the overzealous dentist became anxious to correct this to prevent difficulty. Since most of these patients were older women, in the menopausal age, they had been accustomed to whatever peculiarities of occlusion they had for many years, and to change the occlusion at this point in life was a much more difficult undertaking than the dentist seemed to realize. Had the patient been relaxed, the dental procedure might have been well tolerated; but invariably our psychiatric case histories disclosed a life pattern of mounting tension, increasing depression, often to the point of having suicidal thoughts. Superimposed

on an intolerable life situation, the dental therapy was then intolerable because it acted as the last straw.

There is a scientific basis for this type of correlation. Since the so-called nervous person has been shown objectively to have an increased sensitivity to pain, it is as though the nervous pathways were already well loaded before the extra stimulus was applied, and the summation of the two adds up to a different result than in the person whose nervous system is more at rest. It has also been shown by giving bite tests to large numbers of patients that many of them under nervous tension feel pain with much less pressure than the so-called well-adjusted or satisfied individual. Current concepts concerning the nature of the pain process emphasize the separation between two component parts, the perception of pain and the reaction to it. Both perception and reaction are regarded by most neurophysiologists as essentially psychologic terms, as both contain a large subjective element. Avoidance of a painful stimulus is a learned response, so that the influence of past experience is obvious in any group of patients studied. The mechanism for the influence of psychologic factors on pain response is thought to be through a neuronal pool between sensory and motor components in the spinal cord. Thus, past pain experience may set up a closed, self-re-exciting chain reaction within this pool. This concept has been used to explain such self-sustaining pain patterns as causalgia, but it would also help explain hypersensitivity to pain based on past trauma. Therefore, when the patient responds to dental manipulation in a way which seems excessive, it does not necessarily mean that he is "merely exaggerating." This would make it seem as though the patient were purposely bedeviling us and blaming us.

Certainly, many patients use their symptoms as a hostile weapon against the doctor, particularly when they have begun to be dissatisfied with their treatment. However, this is not necessarily so, and almost never occurs at the beginning of a patient's relationship to his dentist. It is usually the result of long-standing misunderstanding between the patient and the doctor, or follows unsatisfactory therapeutic relationships with previous doctors. Whenever the doctor fails to understand the process causing pain, the patient often has a hostile reaction to the lack of understanding, and then begins to use his complaint with increasing hostility and blame. If pain is out of proportion to the visible structural lesion, we are often likely to deride the patient as though he were malingering. I think it is important to remember that pain is an important method which modern people use to communicate to the doctor that they need help.[4] The more their total human problem is understood, the less they need the pain as a way to get some attention and help from outside.

When pain occurs in an emotionally upset individual, it differs in many ways from that typically resulting from specific neurologic or structural lesions. It is often described by the patient in a rather bizarre fashion, with an unanatomic radiation that does not follow nervous pathways. The pain tends to be diffuse, to have no consistent neurologic pattern, and may have many irrational meanings to the patient. In this way it differs from trigeminal neuralgia, for instance, which has a very unique and specific pattern. The neurotic patient

tends to use the pain descriptively to express many other fears, such as "The pain makes me blind or deaf," or, "It makes me feel as though my blood vessels are being torn from my head," or, "I can't face the world when I feel this way." Usually the patient has many other symptoms of anxiety, such as dizziness, choking feelings, insomnia, and multiple gastrointestinal complaints, such as anorexia, vomiting, or diarrhea. Psychosomatic symptoms referable to the gastrointestinal tract have been a frequent complaint of patients who have temporomandibular joint pain, glossodynia, and other intractable dental symptoms, which have no structural basis.

Another frequent irrational complaint in our temporomandibular joint patients was that their faces appeared to them deformed. These patients felt they had a crooked smile, a swelling of the cheek, or did not look like themselves. Invariably where this bizarre complaint occurred with no outside validation, i.e., delusional, the patients were much sicker psychiatrically than they were in a dental sense. Four of the five who made this complaint were schizophrenics, some of whom later had to be hospitalized. Other patients complained of an excessive awareness of jaw motion, such as sensations of banging and clicking, or difficulty in opening and chewing. This type of complaint usually indicates an undue focus of attention on the mouth, which is then an indication that it is being used as an outlet for anxiety.

Many of these observations can readily be made by the dentist in taking the original history of the presenting complaint. An hour's psychiatric examination of these patients revealed much deeper sources of unrest lying behind these more superficial observations. Only four of thirty-five patients sent to me seemed to be relatively healthy people. They had problems in living, as everyone does, but they seemed to be handling them in a way not too different from the average person. The other thirty-one patients were conspicuously anxious and tense. Eleven were psychotic or prepsychotic, and in ten depression was extremely marked. They tended to be a very masochistic group of people, who suffered a great deal of bodily pain in connection with their problems in living. They reported many other painful disorders, such as headache, backache, sciatic pain, etc. Often when a new pain occurred, the old one lapsed, so that one seemed to take the place of another. These characteristics are also typical of reported cases of atypical facial neuralgia or hysterical face pain as distinguished from true trigeminal neuralgia.[5]

Marriages were conspicuously miserable in twelve instances. An outstanding characteristic of the patients was their strong anger, which required inordinate effort to repress and control. The patient would often clench her teeth rather than risk saying what she felt. Her fear of expressing anger was often due to her dependency upon either the husband or the mother, whose reaction she feared. The most typical example of this was a menopausal woman who had been forced to go back to work because her husband became a cardiac invalid. She would become so enraged at her dilemma and at her husband's complaining that she would shut herself up in the bathroom, clenching her teeth to hold back her rage. She had originally gone to the dentist very upset about herself but only needing to have her teeth cleaned. The occlusal rehabilitation that he recommended was the last straw because she was already so tense that the added strain of trying to read-

just her occlusion was more than she could handle. She had increasing pain and insomnia, which almost led her to the point of an agitated menopausal depression. Obviously, it was not the problem of the dentist to try to give her psychotherapy, but recognition of the depth and extent of her outside problems, and the minimal nature of her real dental problem, led us to recommend that the dentist do minimum amounts of treatment on her at one time, and certainly not try to readjust a slightly abnormal occlusion of long standing. Occlusal patterns seem to vary greatly according to the individual, and rigid ideas as to the "right bite" often require more flexibility than is possible for older patients with a rigid character structure.[6]

TYPICAL TEMPOROMANDIBULAR JOINT CASES

Although we have most frequently seen temporomandibular joint pain without structural basis occurring in menopausal women, it has also been noticed in older men. One of these was a man of 51, who had had pain on the left side of his face and a clicking in his left temporomandibular joint for four years. He dated it from a time of an airplane trip and first consulted an otolaryngologist. Later he went to a dentist who injected cortisone into the joint, with no relief. Since the pain was left-sided, he also was worked up at one point to investigate the possibility of either tumor or tic douloureux. However, at no point was any pathology found. Investigation of his recent life pattern showed that he had had a series of life dilemmas for the last five years. His wife, by whom he had two children, died very suddenly in an automobile accident, and he was left alone. He remarried, as quickly as possible, a woman who very shortly afterwards had a psychotic episode. She had had a previous one earlier in her life but had not told him of this, so that he felt duped. It was on an airplane trip to visit her relatives to see about her hospitalization that he developed the first pain in his ears. During the process of getting a divorce from her, which was attached with many difficulties, his pain became worse and seemed more localized in the jaw. As soon as the divorce was obtained, he quickly remarried a woman who had also had two traumatic previous marriages. For a while he felt better, but problems developed here which were difficult to work out. He discovered that this third wife had also been in psychiatric treament before, and again he felt betrayed. He finally had an episode of severe depression, took an overdose of sleeping pills and required hospitalization on a neuropsychiatric floor. Following this he finally started some psychiatric treatment of his own. At this point the patient's pain began to decrease. However, at no point during this process had any physician or dentist suggested that there was any relationship between his life upheavals and the pain in his ears or temporomandibular joint. It was not until he came to New York for consultation that the connection was elucidated for him. He felt quite relieved because it made sense to him and he no longer felt the need to seek an answer for this specific physical symptom. It was suggested that he not try to wear the appliance which had been made for him in an effort to increase his occlusal vertical dimension. His complaints were that this caused more pain, but he was afraid to go without it until "given permission." It was also interesting to note that he had had a peptic

ulcer early in his life. This, plus his rapid remarriages, suggested strong dependency needs, which, when frustrated, left him with great anxiety which finally focused itself on the jaw.

Another example was seen in a man of about 50, who first noticed tinnitus. Someone suggested to him that this might be related to his occlusion, and he immediately became anxious to have extensive occlusal rehabilitation. He was so desperate to find a quick solution for this that he embarked on a prolonged procedure while his own dentist was on vacation, because the possibility of jaw deformity or malocclusion made him so anxious that he demanded immediate help with it. He was a short, stocky man, with a rather severe limp and back deformity caused by a childhood accident. He was a brilliant lawyer and had spent a great deal of his life proving his competence in verbal discussion and argument to make up for his lack of physical strength and beauty. His mouth had very special meaning to him because he had always felt that his teeth were the most beautiful part of him, and of course in the legal profession proper use of his mouth and jaw seemed unduly important. He was conspicuously dependent on his tall, attractive wife, who accompanied him on all of his dental appointments. He had a syndrome of depression and fear of professional inadequacy, which is rather typical of the menopausal age. He was suffering from sexual impotence, which was extremely frightening to him. Whereas as the previous male patient discussed was already receiving psychiatric help and merely needed reassurance that this was a valid approach to his problem, this second man was very hostile to psychiatry. With him it was most useful to discuss his problem with his general physician, whom he had seen for many years, and in whom he placed great trust. His physician was then able to reassure him about the lack of severe organic disease and to discourage him from proceeding with radical mechanical treatment of his jaw.

In contrast to this older age group, the very young adults whom I have seen in consultation tend to complain more of trismus than pain. Several examples of this have been seen in high school and college students who have been under undue pressure for their years. One example was a girl of about 20, who developed trismus in her last semester in college. She had always been a good student, but was very uncertain what she would do when she finished college. Crucial decisions faced her that had to do with jobs, possible marriage, and leaving home. She was also very torn about her loyalty to a Zionist Movement, as she had originally planned to solve all of these problems by going to Israel. As her sureness about this waned, she was left with alternatives that made her quite anxious, and the most clear-cut symptom resulting from this was trismus, which made it very hard for her to eat.

Another example was seen in a high-school-age girl who was trying to support herself and live away from home while finishing school. There was a great deal of conflict at home, and she had ostensibly emancipated herself in a remarkable way for her age. However, it meant that she had to make an effort to be a great deal more independent and mature than she obviously really felt. She also was confronted with problems having to do with marriage and with jobs, as well as her very strained relationships with her parents. A remarkable observation was made by the dentist treating her. He had a very good relation-

ship with her, and although he did no prodding for psychiatric material, she felt confidence in him and burst out one day with some of her problems. Following this, the aperture of her mouth increased by 15 millimeters, due to the relaxation of tension that followed conversation with a sympathetic person about her difficulties. This girl was eventually referred to a vocational counsellor and encouraged to talk more directly to an appropriate audience.

A third example was seen in a 16-year-old high school boy, who developed trismus at a point where he was very much in the limelight because of a mechanical robot that he had made. He had always been under the domination of a younger brother, who was brighter, more aggressive, and much more successful than he. The father had some understanding of this unfortunate competitive situation and a real appreciation for his older boy's, our patient's, slower pace. He tried to encourage him about the robot but seems to have overdone it, because the patient then wanted to make an eight-foot robot after he got the present one under radio control. There had been a newspaper article and undue publicity which had only put the boy under increased tension rather than reassuring him about his abilities. The mother was described as a very perfectionistic and overprotective person, who not only put great pressure on the patient for good grades but was much too preoccupied with his oral symptoms. He had first noticed trismus while with his mother and brother on a Sunday afternoon ride, and the mother immediately took him to an emergency ward, as though the situation were extremely dangerous. The boy said that the trismus did not particularly upset him, and he readily described himself as tense and muscle-bound, and would not have been preoccupied with his symptoms had not the important adults around him been unduly worried. In this instance our recommendations were to lessen the pressure on the patient for achievement, put less attention on the trismus, so that the patient be allowed to forget it, and to have a consultation with his local dentist so that his work might be more in line with that recommended by the dental consultant.

It is interesting to note that like most oral psychosomatic symptoms, temporomandibular joint dysfunction and pain seem to be more common in women. There are several possible factors that may help to explain this. It has been suggested that women have more free time available during the day to come to clinics, and in our experience it is true that more male patients with this problem are seen in private practice than in the clinic. However, peptic ulcer, for instance, is much more frequent in men, whether seen in a clinic or elsewhere. Another aspect is that the mouth lends itself more readily as a sexual symbol in women than in men. The mouth is more important as a source of beauty and sexual attractiveness in women, who often act out sexual conflict through the use of this zone. When the mouth is used for psychosomatic symptoms by the man, it is often to express anxiety about potency problems or homosexual conflict. One good example of this was seen in a bright young writer who had always been afraid of competing with his very potent father and three older brothers. He was very dependent on his mother and later on an older woman in charge of the department where he was teaching. He first complained of trouble in his occlusion a few weeks before leaving on a Fellowship in a foreign country. He felt very isolated

and lonely there, and had his first homosexual contact with a man old enough to be his father. Complaints relevant to his jaw were so disturbing that they were a significant element in making him turn down a renewal of his Fellowship so that he could return to this country. He was advised to have extensive occlusal rehabilitation, but had a fight with his family about the money required for this. When seen, he was in a very anxious mood, trying to support himself by writing about his trip. He described sitting for hours at the typewriter, tense and lonely, with no one to speak to, and clenching his jaw fervently until by the time hunger drove him out he was unable to open his mouth to eat. He would solve this often by having a drink or finding someone to talk to. In either case the jaw muscles would finally relax enough to allow him to eat. Although he was in his thirties, his dependency needs were so enormous that he could only achieve some kind of intimacy with an older woman, none of whom he could find, or with an older male lover, whom he could find more readily. Attention was directed to his deep-seated problems with people, and psychiatric consultation was recommended as being more pressing than occlusal rehabilitation.

THERAPEUTIC CONSIDERATIONS

It is important to emphasize the ways in which the dentist may modify his approach to anxious patients. Most of them are not desirous of psychiatric treatment. Many of them are not accessible to it. A thoughtful, cautious dental approach, based on some knowledge of the tensional factors involved, is often much more useful than any effort to make direct psychiatric interpretations for which the patient is not prepared, nor is the dentist prepared to give them. The dentist may draw the patient's attention to oral habits that are deleterious, such as grinding or mere clenching of the teeth. Patients will often deny this when first asked, but later realize how they awaken with clenched, tight jaw muscles. They may be able to achieve some voluntary control when they become aware of the habit and realize its role in causing their symptoms. Making a connection between anxiety and physical symptoms helps to redirect the patient's attention to the real source of his difficulties rather than chasing a red herring. One does not need to refer patients to psychiatry or take a psychiatric history in order to gather some relevant data about the role of anxiety in producing their symptoms. Many of them will give material without being asked. Others will show definite signs of anxiety, which are readily observed by anyone interested in looking. The way in which patients describe their symptoms, the kind of so-called nervousness or tension or embarrassment which they show in describing their difficulties, the irrational connections they make between pain and its effect on their lives, all give the dentist evidence that emotional factors are playing a significant role. There may be other psychosomatic symptoms, such as the gastrointestinal complaints mentioned above, which are also telltale signs. It is very important to get an adequate dental and medical history on patients, particularly to find out what kind of relationships they have had to previous dentists. Very often a history of past mistreatment at the hands of dentists, or past unsatisfactory relationships with dentists due to the patient's neurotic needs, will forewarn of impending trouble,

which may then be avoided. Many thoughtful dentists suggest that the last dentist treating a new patient be contacted about his experience with the patient, particularly if a prolonged procedure is to be undertaken. This kind of continuity would prevent repetition of the same harmful patient-doctor pattern.

Often a temporal correlation can be made between especially stressful life situations and the outcropping of physical symptoms. This temporal correlation may then suggest the psychogenic nature of the disorder. How much one communicates one's concept of the nature of patients' problems to the patient depends on his ability to utilize the interpretation. The dentist may merely modify the speed and extent of the treatment, based on his understanding of the patient's difficulties; or he may specifically direct the patient's attention toward this, and even, if he feels it is useful, suggest psychiatric consultation.

The dentist plays a most important role in directing the patient to rational methods of treatment, or even to stay away from additional dental treatment if necessary. When symptoms are poorly understood, or no physical basis is found, there is a temptation to play it safe and send the patient to some other specialist, thinking "it can do no harm." Surely this is wise if there is real doubt as to structural pathology, but often referral is done to be rid of a tiresome patient or to avoid being blamed, even when one is relatively sure about the tensional basis for pain. This can do harm, as patients often seek refuge in physical causes and prefer not to notice problems in living that beg for attention. Often patients are only too anxious for some radical dental treatment, which may appear to them to be a magic cure-all, which inevitably fails to make them feel better and often makes them feel worse. For instance, injection of sclerosing solutions into the temporomandibular joint invariably makes more pain. What is frequently needed is a slow tempo of treatment, with a minimum of difficult procedures and manipulations. In this sense it is often much better to apply ethyl chloride spray, which is a simple, nontraumatic procedure, rather than to use multiple injections or prolonged dental procedures. Repeated mouthwashing or simple exercises of the jaw muscles may also facilitate relaxation. Exercises for spastic jaw muscles need to be rather carefully prescribed and explained, as patients will often try to do them in a rigid, abrupt way, which is traumatic rather than relaxing. One cannot jerk stiff muscles into opening up. The goal is to relax them by some kind of easy-going, unstrained physiolgic usage. To prescribe "relaxation" in a way that a patient can use it, often requires some knowledge of the patient's way of life. A vacation in a resort may be a hurdle to some patients that increases strain. Often it is useful merely to let a patient know that one feels she suffers from a tensional syndrome, rather than one due to real structural pathology which may be dangerous. This may be quite reassuring to the patient who fears cancer or becomes alarmed by the more radical dentist and feels the need for extreme procedures. Often the dentist who recognizes the role of anxiety in producing or aggravating symptoms may merely use this knowledge to vary the extent or tempo of dental treatment. This may, in turn, prevent a crescendo of unnecessary complications.

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COMMENTS ON PSYCHOLOGIC ASPECTS OF DENTAL TREATMENT*

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FOR MANY YEARS PHYSICIANS and other social scientists have been searching for meaningful and precise and predictable explanations for specificity or "choice of organ" in the complex psychosomatic process. And while much has been learned, I would suspect there is still a long way to go before we will have a workable fund of knowledge for the practitioner and the "prophylactician" to draw upon. Studies of the type Dr. Moulton has undertaken are contributing to this ever-growing body of knowledge.

I would like to restrict my remarks to research design, and point to some areas and ideas I feel are important for future studies of the kind which has just been presented.

Dr. Moulton has utilized sociologic and psychologic factors in her observations, as well as the influence of one upon the other in producing physical symptoms. It is sometimes hard for those not acquainted with dynamic psychiatry to understand that emotional disturbances may lie dormant for years—indeed for an entire lifetime, and appear only when the individual is subjected to sudden sociologic stresses which overtax his resources, and call for adjustments beyond the capacity of his defense system. It is at this point that the ego struggles to maintain integrity, and these are the crucial periods in the total life adjustment of the individual. And too, a person may weather one storm and not another. A residual of trauma often prepares a path for future breakdown comparable to the aftereffects of scar tissue upon the functioning of organs. Studies of displaced persons, those faced with sudden catastrophe, and the induction of young men into the new social environment of military life are replete with examples of the use of desperate means to maintain psychologic equilibrium during a crisis. Some cannot meet the new demands even for a day, and yet others struggle many years only to break down physically with peptic ulcers, or tuberculosis, a psychotic disorder, or difficulty centered in the mouth. From all we know, we believe the organ breaks down with specific meaning both longitudinally and in the precipitating event, but as yet we cannot say why other individuals with like predispositions and comparable traumatic life events do not develop similar symptoms—or develop none at all.

The choice of somatic symptom may also be culturally and socially influenced by the social pressures felt in one's society. Psychosomatic symptoms do change

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The opinions and conclusions contained herein are those of the author and are not necessarily those of the Department of the Navy or the Department of Defense.

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statistically in time and among specific groups of people. Halliday,[1] for example, points out that mucous colitis, confined to women in the Victorian era, all but disappeared around 1914 with the social emancipation of women. He has also shown how the incidence of peptic ulcer has been increasing in men and decreasing in women. Gastric disorders, rheumatism, exophthalmic goiter and hypertensive cardiovascular diseases were shown to be more frequent in urban than in rural areas. Among the social classes, ". . . in both diabetes and hypertensive cardiovascular disorders, deaths in males were greatest in the well-to-do classes but in females in the poorest classes."[2] These statistics merely point out that many factors are at work in the choice of symptom and that, in dentistry, further knowledge about these factors may be crucial in diagnosis and in subsequent treatment, and may help to account for many of the failures which dentists report.

I was most pleased to see in Dr. Moulton's research some direct application to patients. We are all tired of seeing countless articles published in respectable professional journals which report findings from inadequately conducted studies termed "research," but which actually amount to little else than "busywork." And how disappointing are the incoherent studies which report findings involving elaborate experimental design, and which have lost all attempts to ever deal with the very real life problems which we all must face daily in caring for patients. But most satisfying of all, Dr. Moulton has taken on the dual role of researcher-therapist, and has used her interviews as a therapeutic means, as well as for gathering important scientific data from the patient.

I think sometimes, in the name of science, many in the medical and social sciences far overstep their prerogatives in their research relations with patients, and momentarily disregard the inherent trust and respect which tradition has built in the healing arts. Harry Stack Sullivan[3] has said that all relationships can be therapeutic, and I think it would be a real task for the scientist, who works toward understanding more of bodily processes, to gather his information in a scientific manner and not disregard his duties to his profession and to his patients.

But why all this concern with the researcher and his methods. Merely this—I believe that many of the research results on human beings being reported today, contain inherent flaws in disregarding the totality of the individual being studied, and in the personality and motives of the researcher. I think the researcher himself is one of the most neglected potential sources of error in science today. And in the medical sciences, this is often due to the training and role of the practitioner. Harry Wilmer[4] has pointed out that, "Physicians, by tradition and design, tend to consider their patients' behavior *as if* it had nothing to do with their own (unless it be exemplary)."

Dr. Moulton has pointed out the limitations and misconceptions which studies of individual disorders may contain when disregarding the totality of the individual, and the relation of emotions to structure and systems. In these two areas may lie many of the failures of present-day medical research.

PSYCHOSOMATIC ILLNESS

I wonder if physical symptoms can be produced by the individual as a protective device in order to save an already weakened ego from total disintegration,

that is, from losing control and moving into a psychotic state, or at least from the threat of it. Two recent incidents have caused me to speculate about it.

The other day I asked 8 hospitalized servicemen what they considered the worst thing that could happen to them. Several were Marines who had experienced combat in Korea, one had had a young sister die in his arms, another had been in a series of automobile accidents in which 5 people were killed, including his wife. Seven of the 8 responded "losing my mind." These were patients on the psychiatric service for evaluation and disposition, but it had been determined that 7 of them could be returned to their former duty status. Half of them had entered the hospital with numerous physical complaints, and one was an experienced medical technician. The one who did not respond like the others was a young marine in an early schizophrenic state with many paranoid features and somatic complaints. Perhaps he was too close to mental illness to realize the public's fear of it. The next worst thing they agreed that could happen to a person was to lose his sight, and the third seemed to be the loss of a person's limbs. This reminded me of the social pressures people feel regarding the kind of disorder, and the "social respectibility" of various types of disease and treatment. It is somewhat embarrassing to have braces on one's teeth, but this is not as bad as any sort of facial disfigurement. In turn, this is not as bad as a "social disease" such as gonorrhea or a dreaded disease like cancer, and these are not as bad as a mental disorder. Yet the curious paradox is that people die from physical illness every day. Rarely do deaths occur from emotional disturbances, and most mental disorders can be treated. I imagine that most dental disorders are quite respectable socially.

Recently a colleague remarked to me that he had been talking to a woman with tuberculosis, and had suggested to her that perhaps her emotional state was contributing to her discomfort. She desperately replied, "Doctor, isn't it enough that I have to suffer like this without you saying I'm crazy too?" To her a disease process which was slowly taking her life was not as bad as losing control emotionally, and yet the physical disease was accomplishing just that. It was preventing her from realizing her emotional conflicts, and at a terrific cost in irreversible tissue damage.

Perhaps some more research into the multiplicity and "layers" of psychosomatic symptoms together with their relative degrees of social acceptability would provide useful information for treatment of dental disorders. We would then know more concerning how and why some dental patients avoid seeing their life problems and meeting them. We could thus understand why they need to resort to such physically destructive (yet apparently ego preservative) means to cope with life. It is possible that we could more adequately meet their needs, rather than further their futile attempts to master situations. We need to tighten up our research designs. With the advent of "Q" methodology, which Stephenson[5] has introduced to America, and the new possibilities which it presents for studying individual patients, we can now study "samples of one," scientifically.

Considering pain itself, do we really know the degree of pain a person feels? We have no means for measuring pain or pain thresholds in various areas of the body, and in different persons. We know that old anxieties centering about pain, revived under new trauma, contribute or detract from the degree of discomfort.

Many patients, on coming to the dentist's office, are ready to experience pain as this is socially "expected" within dental treatment.[6]

I would like to stress again the importance of an awareness of social and cultural "pressures" on the dentist and in the dentist-patient relationship. It seems that as we progress in the healing arts, we place constant expectations on ourselves, and others place them for us, to have "answers" and not to admit to lack of knowledge. How much more therapeutic it would be if we could all admit that sometimes there is no answer, and sometimes even the best truth is "subject to change without notice." We could then help people to live with themselves as they are and with their ailments; that these factors limit a person only to the extent he lets it happen. Sometimes I think this *is* the answer. In Japanese psychiatry, one kind of treatment is to put the patient in bed for seven days, allow him to talk to no one, just to think about his ailments and learn to accept them. Gradually he returns to normal social living and reportedly at the end of forty days, 85 per cent have recovered, or are sufficiently improved to lead normal useful lives.[7]

Continual progress in the healing arts demands our examination of not only medical techniques, but the emotional climate in which treatment takes place, of the individuals performing the treatment, and the entire make-up of the patient. As practitioners and as researchers we must continually ask ourselves:

"Can I myself really give
Have I really given
Can you give?
And have you really given?"[8]

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A STUDY OF THE ARBITRARY CENTER AND THE KINEMATIC CENTER OF ROTATION FOR FACE-BOW MOUNTINGS*

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THE VALUE OF THE FACE-BOW has been the topic of considerable discussion and controversy in prosthetic dentistry for many years. Logan[1] has considered it to be indispensable in denture construction. Stansbery[2] and others[3] consider it to be useless. Before we study the significance of the arbitrary center and the kinematic center of rotation for face-bow mountings, let us first briefly review the history of the face-bow and the significance of its application.

A considerable amount of investigation and experimentation preceded the development of the face-bow as we know it today. Bonwill, Balkwill, Hayes, and Walker were all aware of the importance of maintaining the relationship of the ridges to the condyles when transferring occlusal recordings to the articulator.[4] In order to maintain these relationships, various methods were employed. Bonwill[4] used a measurement of 10 cm. from the center of each condyle to the median incisal point of the lower teeth as his guide. Balkwill[4] devised an apparatus whereby he could measure various angles and mount accordingly. Hayes[4] introduced the "Caliper," and Walker[4] invented the complicated "Clinometer." All of these methods and devices fell short of the desired result, however, and it remained for Gysi[5] and Snow[6] to introduce their classical face-bows, at nearly the same time, before desirable results were achieved. While Gysi's face-bow was actually a combination face-bow and tracing device, thereby capable of obtaining more than one positional relation record, it lacked the simplicity of Snow's unifunction face-bow. In view of this, Snow has generally been given credit for its introduction. Few improvements have been made upon Snow's original face-bow, which corresponds to the Hanau model C face-bow of today. The only major development of Snow's face-bow has been the introduction of the adjustable or kinematic face-bow which is capable of determining the rotational center of the hinge-axis of the condyles. In contrast to this, Snow's face-bow depends on an arbitrary center of rotation.

ADVANTAGES OF THE FACE-BOW

It has previously been stated that the value of the face-bow is a highly controversial subject. Advantages and disadvantages have been set forth; the usefulness

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and uselessness of the face-bow has been expounded; and opposing theories have been developed. Lazzari[7] has set forth the following list of advantages for using the face-bow:

"(1) It permits a more accurate use of lateral rotation points for the arrangement of teeth.
"(2) It aids in securing the anteroposterior cast position with relation to the condyles of the mandible.
"(3) It registers the horizontal relationship of the casts quite accurately, and thus assists in correctly locating the incisal plane.
"(4) It is an aid in the vertical positioning of the casts on the articulator."

These advantages lead us to believe that proper use of the face-bow is a valuable aid in denture construction. However, some authors claim that its use is not a necessary step. Stansbery[2] has contended that the face-bow is useless, and has described a technique of obtaining positional relation records which does not require use of the face-bow. Craddock and Symmons[8] in their comprehensive evaluation of the face-bow have concluded that its use is not a necessary step in denture construction. However, the general consensus in prosthetic literature appears to be one of acknowledging the advantages of the face-bow and favoring its use. Considering the diversified views on this subject, and with the contention that there is no room for dogmatism in any scientific field, one may conclude that a mean exists somewhere between the extremes. This mean could be a statement that the face-bow is neither useless nor indispensable, but that it offers certain advantages when used properly, and therefore merits a place in prosthetic dentistry.

THE ARBITRARY VERSUS THE KINEMATIC FACE-BOW

If the assumption is made that the face-bow has a place in denture construction in connection with the use of a semiadjustable articulator such as the Hanau model H, the question arises as to whether the conventional Hanau model C face-bow should be used, and set to an arbitrary axis, or the kinematic type of face-bow should be first employed to determine the actual axis of rotation. While we should always strive for accuracy in maintaining relationships, and while the use of the kinematic type of face-bow is a more accurate procedure, general use of such a face-bow may not be the most practical one. The use of the kinematic face-bow calls for a greater initial investment and a rather lengthy and difficult procedure. If the advantages resulting from use of the kinematic type of face-bow are sufficient to offset these disadvantages, then, by all means, its general use should be established. It has been stated by Arstad[9] in his treatise on mandibular movements that ". . . an error of 5 mm. from the hinge-axis results in an error of only 0.2 mm. in the articulator, i.e., after a hinge movement of 2 mm. in the articulator, the molar of the lower jaw model will have contact with its antagonist 0.2 mm. mesial or distal to the intraoral occlusal position of the molar after a corresponding mandibular movement of 2 mm." This has been partly substantiated by Schuyler[10] with the provision that such recordings take place in proper centric and vertical relationships. Because of this 5 mm. tolerance with the resultant negligible error, many feel that it

is not necessary to determine the axis accurately. Arstad[9] has stated, "To locate the patient's hinge-axis, however, is an exceedingly difficult and time wasting task." Schlosser[11] contends that although the arbitrary axis is not precise, it is close enough for all practical purposes, and he bases this contention upon years of clinical experience. However, only Beyron[12] has reported scientific data comparing the arbitrary with the actual hinge-axis. Beyron's report includes 39 cases, of which only 10 were of "normal" occlusion. In order to evaluate further the relationship of the arbitrary to the actual axis, determinations were made on 70 dental students under the auspices of the Department of Prosthetic Dentistry of the Marquette University School of Dentistry, and the results were compared.

PROCEDURE

Seventy dental students were selected on the basis of normal occlusion and full complement of at least 28 teeth for the study. Alginate impressions were made of the lower arches, and stone casts were made. Large undercut areas were filled with Tenax wax, and a splint was molded over the teeth with self-curing acrylic resin. The face-bow fork was embedded in the resin splint while plastic, and the acrylic resin was allowed to cure. The fork was then removed from the splint, and the splint was removed from the cast (in both cases, a mechanical lock was created). The splint was then trimmed (Fig. 1). The patient was instructed to practice opening and closing the mandible in a centric relationship through an arc of about 10 mm. at the incisor region. Marks were placed on the nose and the chin, and measurements were taken while the mandible was in rest position and in centric occlusion. The splint (without the fork) was placed over the mandibular teeth and checked for mechanical lock, tissue and cuspal interference, etc., and the splint was retrimmed until the measurement taken while in occlusion with the splint was less than 2 mm. over that in occlusion without the splint. Strips of adhesive tape were placed over the condylar area, and a line was drawn from the center of the tragus to the outer canthus of the eye. On this line, the arbitrary axis was plotted 13 mm. anterior to the posterior margin of the tragus, and the tape was identified by the side and the number of the determination. The fork was then fastened to the splint (Figs. 2 and 3) and the Hanau model H face-bow attached to the fork (Figs. 4 and 5). By a process of trial and error, the axis was plotted and marked on each type. (The method was essentially the same as that described by Swenson.)[13] The strips of tape were then mounted on a sheet of paper, and the determined axis points were compared to the arbitrary points, both as to distance and direction (Fig. 6). Cross checks were taken on every fifth subject, either by myself or a faculty member of the prosthetic department, in order to maintain uniformity of procedure and to evaluate the accuracy of the results.

The question as to opening 10 mm. on a purely hinge-axis should be discussed at this point. It has been stated by McCullom,[14] and substantiated by Eberle[15] that the mouth may be opened at least one-half inch on a purely hinge basis. They have also confirmed the belief of many that a definite hinge-axis movement exists.

RESULTS

The results of the comparisons of the arbitrary to the actual axis of rotation are listed in Fig. 7. Concentric circles with radii of 1 up to 7 mm. were drawn around

the arbitrary axis as the center. The individual determinations were not plotted because of their proximity to one another, and the resultant complexity of interpretation. The number of determinations within each radius (R) was listed in the chart under N, and the per cent of the total number of determinations within a given radius was listed under P. It should be noted that 97 to 98 per cent of the

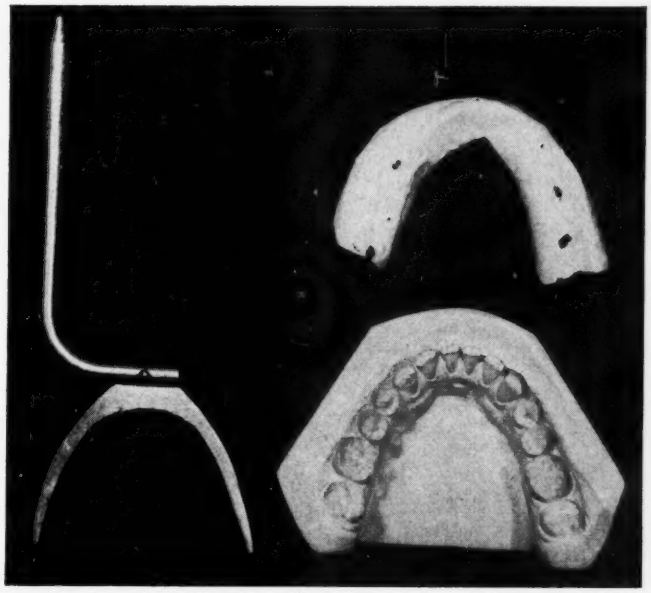


Fig. 1.—The lower cast, face-bow fork, and trimmed acrylic resin splint.

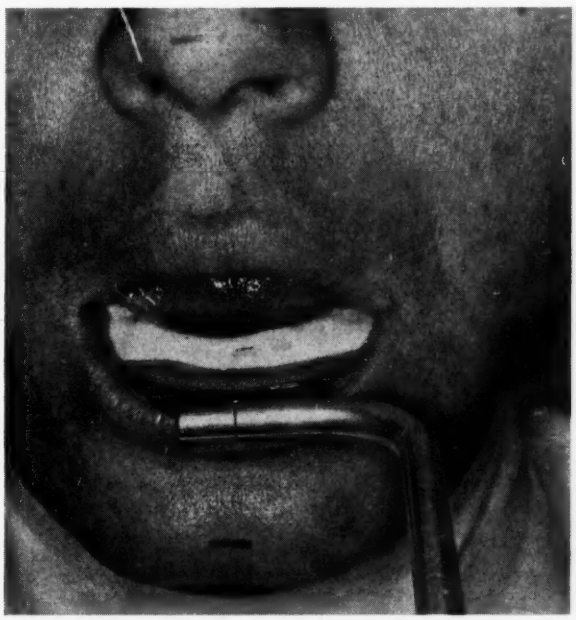


Fig. 2.—The splint and fork in position. Measurements are taken from the mark on the nose to that on the chin prior to the insertion of the splint in both occlusion and rest position and again after the splint has been inserted (without the fork attached). The splint is retrimmed until it adds less than 2 mm. to the closed dimension.

determinations fell within a radius of 5 mm., which is considered by Arstad[9] and others[10,12] to be the limit for negligible error. Although it was not shown in the chart, a notation of the general distribution is also made. For both condyles, the distribution of the determined axis points to the arbitrary axis was fairly uniform

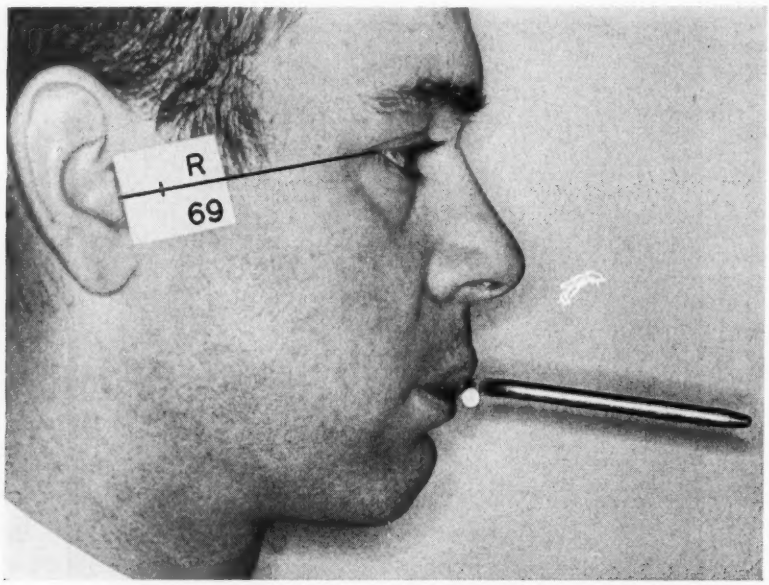


Fig. 3.—The splint and fork in position, and the tape placed and marked (marks are retraced in ink on the photograph for ease of interpretation).

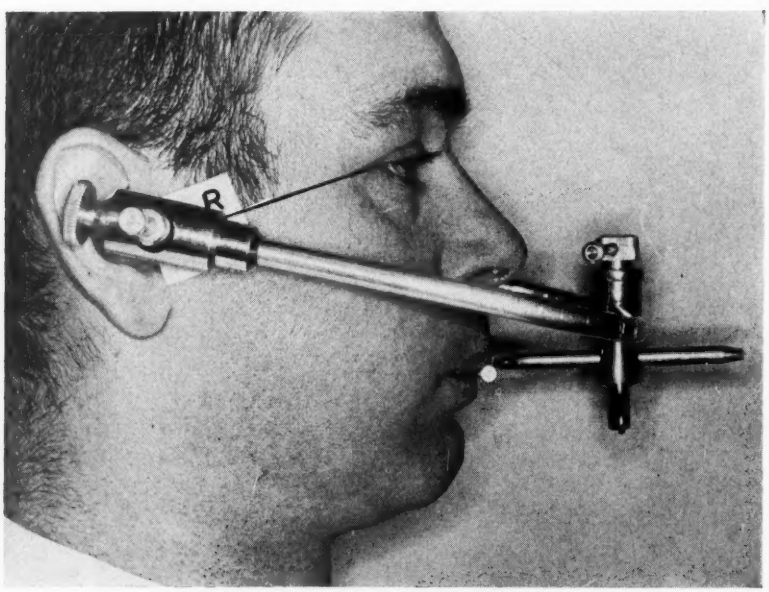


Fig. 4.—The Hanau model H face-bow attached to the fork with the pointer set on the determined axis.

in all directions, with the least number being located anterior and below the arbitrary point. This falls in accord with Beyron's[12] findings that distribution of the determined axis points is general, although slightly more lie posterior to the arbitrary mark. Contrary to Beyron, however, it was found that about 20 of the 70

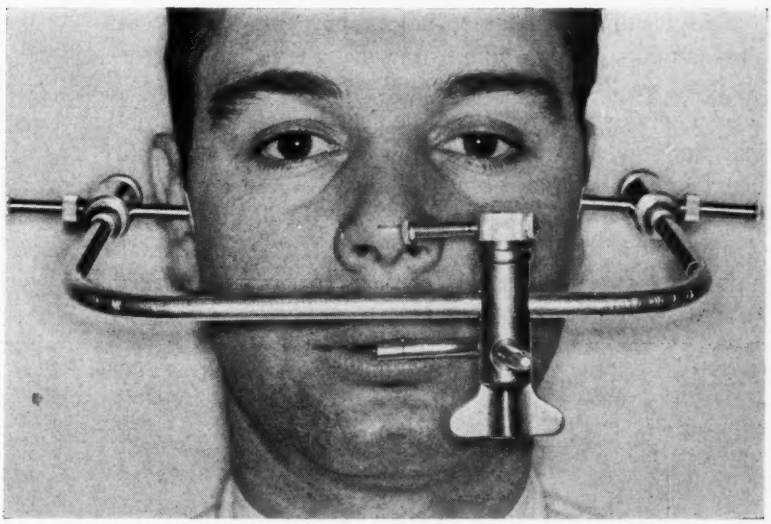


Fig. 5.—The face-bow apparatus.

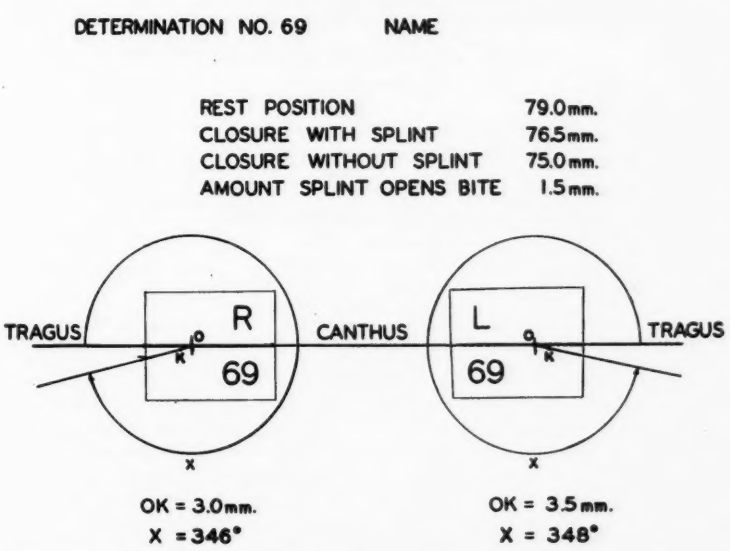
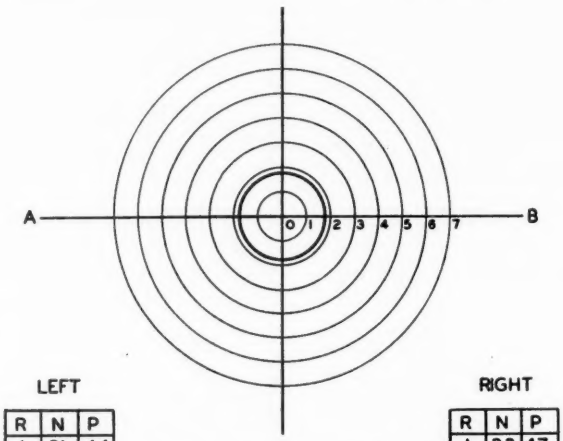


Fig. 6.—Data of an individual subject. The strips of tape are mounted, and comparative determinations are made.

determinations on each condyle were practically on the arbitrary mark. An arithmetic mean *(M)* was computed, and found to be at a radius of 1.7 mm. from the arbitrary axis point for both condyles. This mean radius is represented in Fig. 7 by the heavy circle located between circles 1 and 2. While this figure is small, a

geometric center point which would take into consideration the divergent directions would bring the point still closer to the arbitrary mark.

Since the results of any experiment are only as good as its reproducibility, considerable attention was given to cross-checking the data. Schuyler[10] has stated that no two operators could relocate exactly the same point, and that one operator would have a difficult time doing so unless the point was tattooed. While I agree with this assumption, I would like to say that the actual difference in relocation in most cases is so small as to be negligible. Of the 30 or more actual cross-checks by myself or others on new tape, only one such check was more than 1.5 mm. from the original plotting. In most cases, the error of reproductibility was at a radius of less than 1 mm. from the original plotting. Because of this, divergence in only one of the four basic directions would increase the distance between the determined point and the arbitrary point. Thus, the resultant experimental error on an average basis does not affect the results of this experiment appreciably:



LEFT

R	N	P
1	31	44
2	45	64
3	57	81
4	66	94
5	68	97
6	69	98
7	70	100

M=1.7

AB = TRAGEAL-CANTHUS LINE
O = ARBITRARY AXIS
R = RADIUS IN MILLIMETERS
N = NUMBER OF DETERMINATIONS WITHIN GIVEN RADIUS
P = PERCENT OF TOTAL
M = MEAN RADIUS

RIGHT

R	N	P
1	33	47
2	43	61
3	53	75
4	62	88
5	69	98
6	69	98
7	70	100

M=1.7

Fig. 7.—Concentric circles with radii of 1 to 7 mm. at 1 mm. intervals have been drawn with the arbritrary center of rotation as the center point. The number of determinations for each condyle within a given radius, and the percentage of the total determinations within a given radius are listed in the chart. It should be noted that 97 per cent of the total determinations of the left condyle and 98 per cent of the total determinations of the right condyle fall within a radius of 5 mm. The heavy circle located between circles 1 and 2 represents the mean radius.

CONCLUSIONS

The following conclusions have been drawn on the basis of these results, and the results of others:

1. The arbitrary axis of rotation as set forth by Snow, Gilmer, Hanau, Gysi, and others, of 13 mm. anterior to the tragus on the trageal-canthus line comes

very close to an average determined axis on individuals with normal jaw relationships.

2. One can feel justified in using the arbitrary axis for face-bow mountings on a semiadjustable articulator since, in over 95 per cent of the subjects with normal jaw relationships, the kinematic center lies within a radius of 5 mm. from the arbitrary center, which is considered by Arstad[9] and others[10,12] to be within the limits of negligible error.

3. I would agree with Schuyler,[10] Arstad,[9] and others that the determining of the kinematic center of rotation is not nearly as important as the obtaining of proper centric and vertical relationship records.

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A SCIENTIFIC APPROACH TO THE STUDY OF THE TEMPOROMANDIBULAR JOINT AND ITS RELATION TO OCCLUSAL DISHARMONIES

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THE PURPOSES OF THIS article are: (1) to dispel some of the misconceptions still prevailing in our literature with regard to roentgenographic diagnosis of the temporomandibular joint in health and disease; (2) to demonstrate that the temporomandibular joint and occlusion of the teeth are continually in such intimate and complex interplay that they can never be studied separately, and that the temporomandibular joint ligaments are not merely trivial accessories but important suspension pillars of the masticatory mechanism; (3) to show that the muscles of mastication dominate the masticatory mechanism; (4) to point out that the interocclusal rest space (incorrectly called the "free-way space") is an integral part of the anatomy and physiology of the dental apparatus and should not be tampered with in restorative procedures for esthetic or cosmetic considerations.

THE MISCONCEPTION OF "CLOSED" AND "OPEN" MOUTH ROENTGENOGRAPHIC EXPOSURES

For the past three decades, diagnosis relating to health in function of the temporomandibular joint has largely been based upon the assumption that with a 30 mm. degree of jaw separation, the mandibular condyle leaves the glenoid cavity and places itself in juxtaposition to the lowest point of the eminentia articularis. Any deviation from this allegedly normal behavior of the mandibular condyle has been considered abnormal. This misconception originated in the faulty technique then in vogue for securing temporomandibular joint roentgenograms. Persistence in the same technique has been the belt of transmission of the misconception. This orthodox technique consists of securing two exposures of the joint: (1) with the mouth closed (teeth clenched), (2) with the mouth open 30 mm.

In neither of these exposures are the condyles located where the operator intends to find them. In the first instance, the mandible is supposed to be in centric relation to the maxillae and the condyles in the most retruded *unstrained* relation in the glenoid cavity. This is seldom the case, since "clenching of the teeth" is not the prosthodontist's concept of a centric jaw relation.

The second exposure is secured by instructing the patient to bite on a block of wood 30 mm. wide. The word "bite" in itself leads the patient into a protrusive relation of incision by a conditioned reflex action. In addition, if the

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operator introduces the block of wood from the right side, the patient bites on the right side. Similar results are obtained when the block of wood is introduced from the left side. The alleged opening component that the operator thus seeks to obtain deteriorates into an opening component consisting of a protrusive component associated with a lateral component. These types of temporomandibular joint roentgenograms are faulty from many standpoints. For diagnostic purposes they are valueless. Temporomandibular joint roentgenograms should be secured with *unstrained* intraoral wax records at various degrees of jaw separation.[1]

In addition, these individual roentgenograms should, for comparative study, be superimposed upon one another without changing either the angulation of the rays or the position of the head. The data thus obtained can be compared with cephalometric studies charted against a standardized plane of reference. This, in turn, should be followed up, whenever possible, with cinefluorographic studies of the temporomandibular joint in function. The broad approach to the study of the temporomandibular joint from its various aspects and with the various means at our disposal (topographically, anatomically,[2] cephalometrically,[3] roentgenographically,[4] and conefluorographically[5]) should enable us to correlate structure and function in a truly scientific manner.

INTEGRATION OF STRUCTURE AND FUNCTION AND THE INTIMATE RELATIONSHIP BETWEEN THE ANTERIOR AND POSTERIOR COMPONENTS OF OCCLUSION

It may be of interest to note how medicine and dentistry have progressed along parallel lines. To what extent dentistry has been influenced by medicine is difficult to state. One may conclude, however, that as long as medicine was dominated by the organic concept of disease, dentistry was dominated by the static concept of occlusion. The latter had as its main objectives the description of the anatomy of the teeth and their meeting together as the jaws closed. This was what may be called the organic and technologic period in the development of dentistry. When the medical profession began to detour from its traditional path of always seeking organic disease or foci of infection as the causes of illness, when the concept of functional disease came to the fore and the brain became the focal point as a possible source of pains, aches, distress, and ill feeling, the medical profession became cognizant of the fact that impairment of function is a frequent and important cause of human illness. A great deal of effort and research is being invested now in the study of the function of the human body, rather than excessive concentration on its anatomic description. A similar trend is forging ahead in dentistry. The dynamics in function of the masticatory mechanism is the focal point to which the eyes and minds of our profession have turned. In analyzing temporomandibular joint syndromes, the prosthodontist is inclined to evaluate them in terms of function of the masticatory mechanisms as a whole. The latter consists of two components involving two types of articulations: (1) the anterior component—the "articulation" of the teeth; and (2) the posterior component —the articulation of the temporomandibular joint.

The temporomandibular joint is made up of the condyle and the glenoid cavity, both covered with hyaline cartilage. They are held together by a fibrous sac,

and separated from one another by a disc or meniscus of fibrocartilage. The latter divides the glenoid cavity into two distinct cavities. Both cavities are lined with a synovial membrane which supplies nutrition and lubrication to the joint. The anterior component consists of "articulation" of teeth endowed with cusps of various heights and inclinations, covered with one of the hardest substances in the human body—the enamel. In addition, the occlusal surfaces of the teeth feature grooves, sulci, and fissures which are essential elements in their function.

As we can see, the anterior and posterior components of "articulation" differ greatly from one another. If the occlusal surfaces of the upper and lower teeth were covered with cartilage and separated from one another by a meniscus (as is the case with the posterior component of "articulation"), temporomandibular joint syndromes would be rare. The anterior and posterior components of "articulation" would then function more or less under the same conditions and in the same environment. But then it would be anything but a masticatory mechanism. As the mandible is designed anatomically, the anterior element of "articulation" must be in perfect harmony with the posterior element.

It must be pointed out that the anterior element of the masticatory mechanism which consists of the "articulation" of the coronal portions of the upper and lower teeth ("articulation" of cusps, grooves, sulci, and fissures) possesses in addition a gomphosis type of articulation. The latter represents the articulation of the root portions of the teeth with their respective alveoli by means of the periodontal structures.

It follows then that disharmonies in occlusion may have their primary adverse effect upon (1) the coronal portion of the teeth (attrition), (2) the root portion of the teeth (periodontoclasia), and (3) the temporomandibular joint structures (a feeling of pain and discomfort).

The ill effects of occlusal disharmonies are not limited to these three primary areas, but spread out into a great variety of arthritis syndromes resulting from (1) mechanical, (2) circulatory, (3) neurologic, and (4) psychologic disturbances.

Since arthritis is a common name for all varieties of joint disease, it has been subdivided according to their etiologic factors into four types:[6]

1. *Traumatic arthritis* in which the major etiologic factor is believed to be acute direct trauma to the joint.

2. *Infectious arthritis,* in which a specific microorganism is believed to be the major causative factor.

3. *Rheumatoid arthritis.* The etiology of this type of arthritis is unknown, but disturbances of the endocrine system are believed to play some predisposing role. It involves chiefly the small joints, such as the fingers or the wrist, and tends to attack the muscles and connective tissue around the joint rather than the bones. An outstanding characteristic of this type of arthritis is its occurrence chiefly in women.

4. *Degenerative arthritis,* in which the main predisposing factor is the physiologic aging of the tissues of the joint. While this classification seems to be organized in an orderly and logical manner and may, to some extent, be applicable

in diagnosis and treatment of most joint diseases of the human body, the temporomandibular joint requires special study. This is so because the joint of the masticatory mechanism performs a multiplicity of distinctly unique, complex, and varied physiologic functions that place this joint in a class by itself. It is called upon to function in mastication, deglutition (food and salivary secretions), phonetics, establishment of the physiologic rest position, singing, and the expression of various human emotions, such as laughing, smiling, and gnashing and clenching of the teeth. It also participates in breathing. Function of such a complicated nature requires an anatomic architectural structure correspondingly adapted for such duties.

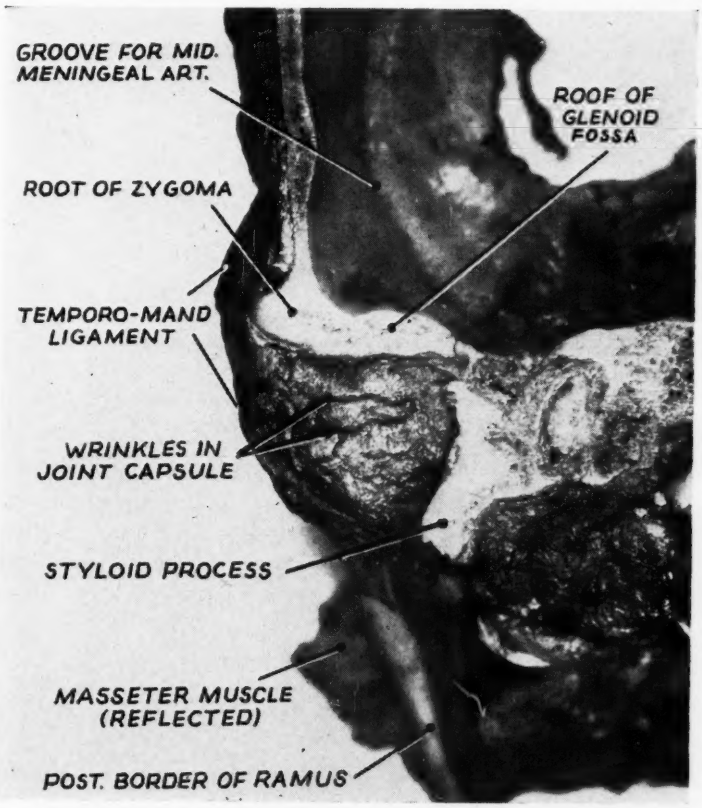

Fig. 1.—The mandible is in centric position. Note the presence of wrinkles in the posterior surface of the joint capsule.

Our recent studies tend to indicate that the temporomandibular joint, when considered from topographic, morphologic, and anatomic standpoints, manifests appreciable differences from all other joints in the human body.

Careful dissection of the temporomandibular joint structures reveals that when the teeth are in centric occlusion associated with a centric jaw relation, all the ligaments of this joint (the capsular, temporomandibular, sphenomandibular, stylomandibular, and pterygomandibular) hang loosely downward, and manifest appreciable folds and wrinkles for this anatomic configuration (Figs. 1 and 2).

On the other hand, when the mandible is placed into an artificially induced "physiologic rest position" (mandibular opening of about 4 mm. associated with its slight protrusion) the wrinkles and folds become distended and obliterated (Fig. 3). Nature has endowed these ligaments with extra length which accommodates the physiologic rest position of the mandible. This observation is fraught with important considerations for our everyday clinical problems. It shows that the physiologic rest position of the mandible is both an anatomic and physiologic entity that cannot and should not be changed arbitrarily when planning to increase the occlusal vertical dimension.

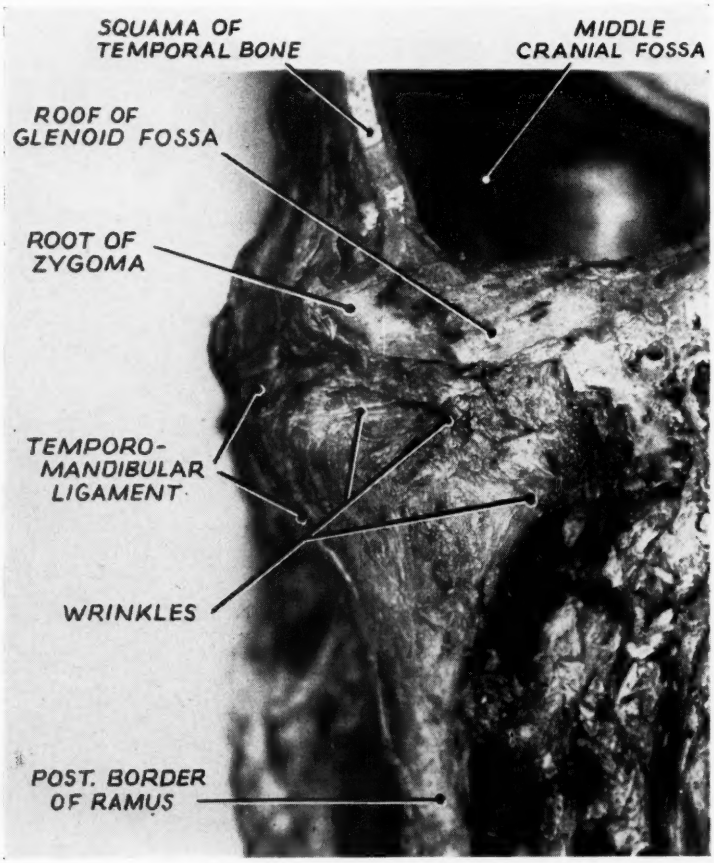

Fig. 2.—The posterior aspect of the left temporomandibular joint. The mandible is in centric position. Note the wrinkles in the posterior surface of the joint capsule.

MOBILITY OF THE MENISCUS

Additional knowledge of the degree of mobility of the meniscus will orient us to a better understanding of the intimate interdependence between harmonious occlusion and the proper function of the temporomandibular joint. Anatomy textbooks state that the mobility of the temporomandibular joint meniscus is equal to that of the condyle, and that the two always move together, whether the mandible goes into a protrusive excursion, a lateral excursion, or a combination of the

two. This is not in accord with our findings from careful dissections of temporomandibular joints of a number of wet specimens, from various aspects and at different angulations. Particularly illuminating and instructive is our new approach of opening up windows (fenestration) through the middle cranial cavities, and inserting surgical needles into both menisci (Figs. 4 and 5).

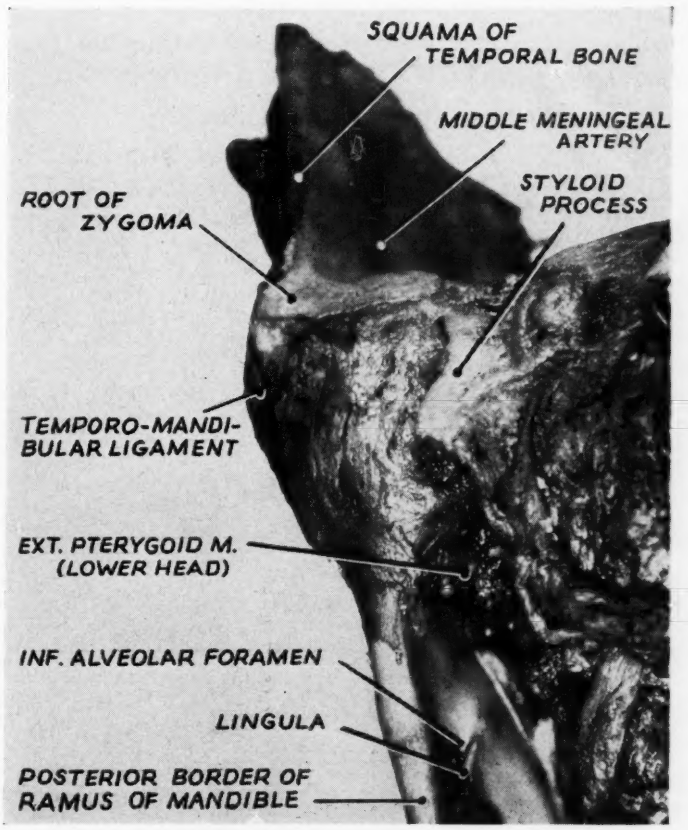

Fig. 3.—The posterior aspect of the left temporomandibular joint. The mandible is in an artificially induced physiologic rest position associated with a slight protrusive position. The horizontal wrinkles are obliterated because the capsular ligament is distended.

TECHNIQUE OF DISSECTION FOR FENESTRATION

The small area in the middle cranial fossa that corresponds to the glenoid cavity at the base of the skull is situated at about the deepest portion of the middle cranial cavity. The mandible is pulled downward and forward, then, with a 702 fissure bur, a small cavity is opened from the middle cranial fossa into the central portion of the superior joint cavity. This is gradually and carefully enlarged until we arrive at close proximity to the capsular ligament attachment to the bony circumference of the glenoid cavity. The finishing touch of removing bony spicules overhanging the superior joint cavity is accomplished by means of fine Chayes stones. Care is taken not to injure the fibrous capsular attachments.

We now insert the surgical needles into the menisci, and proceed with observation of their behavior when the mandible is moved in protrusive and lateral excursions. The mobility of the menisci anteroposteriorly is found to be extremely limited, but a change in their concavoconvex shape is definitely observed. With a protrusive excursion of the mandibular condyles, the menisci flatten out. This is also confirmed by observing the behavior of the menisci on patients that are undergoing temporomandibular joint surgical operations.*

Fig. 4.—The superior aspect of the middle cranial fossa. The roof of the left glenoid fossa has been removed. The superior surface of the meniscus is visible.

PERFORATIONS OF THE MENISCI

The old concept that most temporomandibular joint syndromes are caused by perforations of the menisci which allegedly place themselves in the way of the moving condyles at and near the lowest point of the eminentia cannot be sustained by scientific investigation. The meniscus is not placed between the condyle and glenoid cavity as a nuisance. Our eyes should be turned to occlusal disharmonies as the most important etiologic factor in the causation of temporomandibular joint disturbances. Evidence to this effect is drawn from the great numbers of adolescent boys and girls that are afflicted by this acute syndrome. In most of these patients, it is observed that their six-year molars were removed at an early age

*Personal communication from Don H. Bellinger, D.D.S.

without having been replaced by suitable artificial restorations. As a result, migration of the teeth adjacent to the missing ones takes place, with pathologic patterns of occlusion as a consequence.[7] It is these occlusal disharmonies coinciding in time, as they do, with the important formative stage in the development of the temporomandibular joint, that become the predisposing factors for temporomandibular joint syndromes. The newly established cusp relationship of the migrated teeth interferes with the masticatory stroke, and mastication of food, usually performed by lateral movements of the mandible, is replaced by a chopping up-and-down motion. This, in turn, creates tension with congestion, and improper circulation of blood and lymph in the temporomandibular joint region.

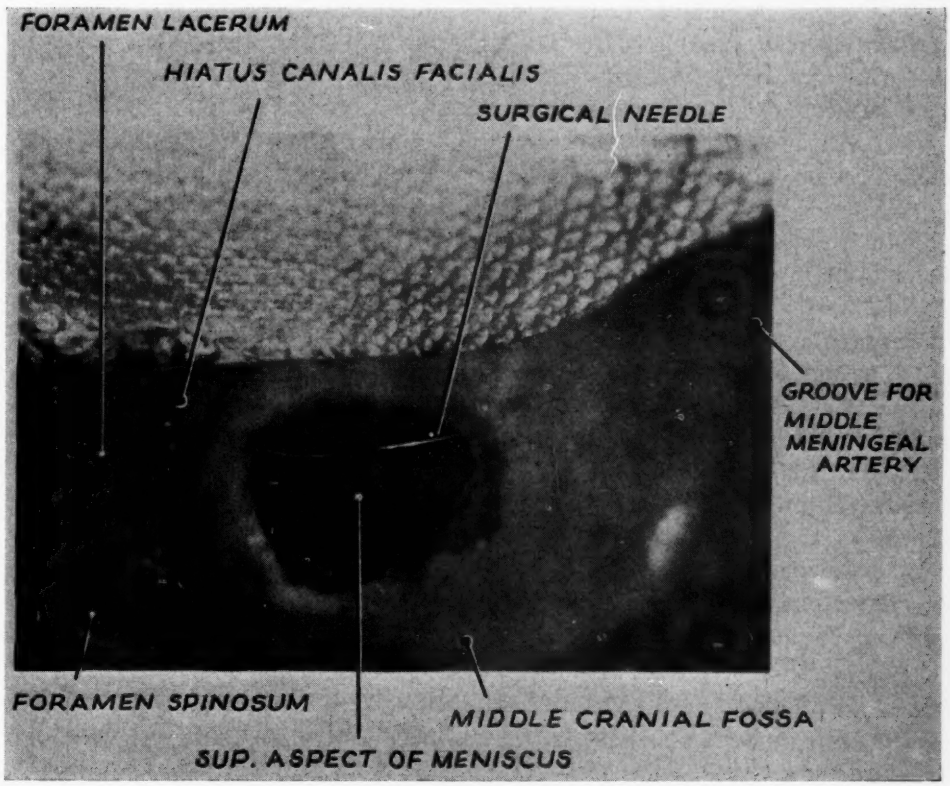

Fig. 5.—The superior aspect of the middle cranial fossa. The roof of the left glenoid fossa has been removed. Note the curved surgical needle inserted into the superior aspect of the meniscus. The mandible is in centric position.

DEEP VERTICAL OVERLAP OF ANTERIOR TEETH

Another type of occlusal disharmony that frequently leads to joint disturbances is the excessively deep vertical overlap of the anterior teeth in which the labial surfaces of the lower anterior teeth are in continuous intimate contact with lingual inclined planes of the upper incisors. This, too, interferes with lateral and protrusive mandibular movements and, in consequence, with the masticatory

stroke. Examples are in Class II cases (Angle classification), with hyperfunction of the masticatory muscles for incision and lateral masticatory stroke, and in Class III cases associated with a crossbite type of occlusion. In this latter instance, tension in the temporomandibular joint may be due to the difficulty the patient experiences in performing lateral movements, and mastication is effected mainly by the chopping motion. Removable partial denture restorations with occlusal disharmonies characterized by lack of vertical and lateral equilibrium constitute a frequent cause of temporomandibular joint disturbances.[8]

Fixed bridge restorations with excessive "bite raising" procedures are most often a cause for pathologic phenomena in the joint structures. The obliteration of the free-way space by these procedures prevents the posterior element of articulation (temporomandibular joint) from assuming its badly needed physiologic rest position, thereby causing congestion and fatigue. Clinical experience indicates that many types of occlusal disharmonies in the anterior component of "articulation" are forerunners of trouble in the posterior component of articulation. It follows that in all restorative procedures of the masticatory mechanism, we should always focus on the elimination of any and all occlusal disharmonies. "Bite-raising" procedures, in individuals past middle age, are always likely to create occlusal disharmonies by virtue of the fact that the mandibular plane of occlusion becomes more obtuse. This in itself would suggest that a slight reduction of the occlusal vertical dimension should be preferred to too great an occlusal vertical dimension.

The slightly reduced occlusal vertical dimension in individuals past middle age may be considered as normal a physiologic phenomenon as the decrease in stature in old people. In the absence of any symptoms of disease in the temporomandibular joint, no "bite-raising" procedures should ever be undertaken with the alleged intention of preventing such symptoms from occurring. The chances of inducing disease by these procedures are greater than their "prevention."

By far the safer way of preventing the temporomandibular joint syndromes is equilibration of the occlusion by means of raising the coronal portions of teeth that are in infraocclusion, and reducing the height of teeth that are in supraocclusion. This is followed up by a reduction of steep inclined cusp planes that interfere with the masticatory stroke.[9] In the presence of clear-cut joint syndromes arising from occlusal disharmonies with a definite *collapsed occlusion,* restoration of the occlusal vertical dimension may be resorted to, but in a very judicious and conservative manner. "Bite-raising," in such instances, of 2 to 3 mm. would be a limit I would impose upon myself. This phase of prosthetic dentistry imposes upon us the study of another very important factor in the production of occlusal and temporomandibular joint disharmonies.

DOMINATING POSITION OF THE MUSCLES OF MASTICATION IN THE MASTICATORY MECHANISM

Excessive increase of the occlusal vertical dimension will always place the muscles of mastication in a state of tension. Because of their dominating position in the function of the masticatory mechanism, disease will be induced in

either the temporomandibular joint or the periodontal structures, or both. The dominating position of the muscles of mastication has been amply proved by the studies of Mershon,[10] Moyers,[11] and Thompson.[12] This feature is also attested to by clinical observation of the behavior of complete dentures in which the established degree of jaw separation is excessive. In these instances, the bone resorption of the basal seats of the dentures that follows is violent in nature, and continues until the excessive jaw opening is reduced to the proper occlusal vertical dimension. It is true that the "bone factor" of the alveolar processes as a basal seat for complete dentures, or as investing structures for the dentition, is of cardinal importance.[13] It is also true that the muscle pattern always persists as the dominating feature, and struggles for the maintenance of its equilibrium at the expense of other structures that are in its way, by getting them out of the way. It follows that occlusal disharmonies in the anterior element of "articulation" are the most frequent cause of periodontoclasia, as well as of temporomandibular joint disturbances through mediation of the dominating muscles of the masticatory mechanism. Judicious and conservative correction of occlusal disharmonies by occlusal equilibration in dentitions and the establishment of balanced occlusion in restorative procedures are the surest way of preventing disease in the periodontal structures and the temporomandibular joint mechanism.[14] In addition, care must be taken to maintain the integrity of the interocclusal rest space at all times.

THE INTEROCCLUSAL REST SPACE AS AN INTEGRAL PART OF THE ANATOMY AND PHYSIOLOGY OF THE DENTAL APPARATUS

The interocclusal rest space (incorrectly called the free-way space) has been subjected in dental restorative procedures to such abuse and martyrization that it has become a major etiologic factor in temporomandibular joint disturbances. The abuse has been arbitrarily applied in both directions by either increasing or decreasing the amount of interocclusal rest space. Some overenthusiastic "specialists" in the field of mouth rehabilitation have been resorting arbitrarily to considerable increasing of the vertical dimension for cosmetic purposes only. Others, in the field of complete denture prosthesis, have engaged in out-of-proportion decrease of the occlusal vertical dimension for alleged mechanical advantages. The proponents of this school of thought feel that since the lower denture is less stable than the upper, the occlusal surface of the teeth of the lower denture should be set as close to the crest of the lower ridge as possible. This concept, when judiciously adhered to, has a salutary effect upon the mechanical stability of the lower denture. But when it is abused, it violates the most elementary biologic principles involved in complete denture prosthesis:

1. It places the plane of occlusion in a disadvantageous position in its relation to the muscles of mastication.

2. It places the plane of occlusion of the lower teeth much too low to enable the tongue to perform its most important biologic function, i.e., to direct the food onto the occlusal platforms of the posterior teeth.

3. It prevents the buccinator muscle from performing its primary function, i.e., to maintain the masticated food on the occlusal surfaces of the lower teeth without "slipping off" buccally.

4. The lateral borders of the tongue spread out upon the occlusal surfaces of the lower teeth, and tongue biting is frequently induced by this procedure.

5. Phonetics is greatly impaired by such an abnormal tongue-teeth relationship.

This partial list of the harmful effects of tampering with the interocclusal rest space (free-way space) should suffice to put us on guard. First, we must rid ourselves of a long-standing misconception that the free-way space and the physiologic rest position of the mandible are one and the same thing. They are not. The physiologic rest position is an anatomic and functional entity in harmony with the masticatory mechanism of which it is a part. It differs greatly in different individuals, and ranges in magnitude between 1.5 and 8 mm.[15] The free-way space is an arbitrarily conceived 2 to 3 mm. space that is supposed to represent the average distance between the incisal edges of the upper and lower teeth when the mandible is in its "physiologic rest position." This arbitrary average cannot, and should not, be used as a therapeutic agent in oral restorative procedures. Yet it is still used by many of our colleagues as the sole criterion in the determination of the vertical dimension. Instead, we should resort to more basic and reliable procedures when seeking to establish the correct vertical dimension in oral restorative procedures:

1. Tests for mechanical efficiency in mastication as elicited from the patient's tactile sense, with occlusion rims and a trial set-up in hard wax.

2. Tests for phonetics by speech-recording procedures at various degrees of jaw separation in the trial dentures.

3. Testing and analyzing the esthetic values of the trial dentures with various degrees of jaw separation. These tests, when executed with scientific and artistic diagnostic skill, are conducive to much better results from a biologic standpoint than the sole reliance upon an arbitrary 2 to 3 mm. free-way space.

SUMMARY AND CONCLUSIONS

1. Roentgenograms secured by the prevailing orthodox method with two exposures ("mouth closed" and "mouth open") are useless for diagnosis of temporomandibular joint syndromes. At best, such roentgenograms may be of some limited value in diagnosis of bone pathology, such as condylar fractures and cases of ankylosis.

2. The anterior component of "articulation" (occlusion of the teeth) and the posterior component of articulation (the temporomandibular joint) are in such intimate interplay that occlusal disharmonies often have an adverse effect upon the temporomandibular joint function.

3. The muscles of mastication play a dominant role in the function of the masticatory mechanism, and they struggle for the maintenance of the status quo of the muscle tonus, in the face of resistance arising either in the temporomandibular joint or in the periodontal structures. Therefore, in a properly functioning

masticatory mechanism, the muscles of mastication, occlusion of the teeth, and the temporomandibular joint structures must be in a harmonious interplay and interdependence.

4. Partial or complete obliteration of the interocclusal rest space in "bite-raising" procedures induces tension in the muscles of mastication, periodontal tissues, and the temporomandibular joint structures. This tension causes interference in the blood and lymph circulation, thereby disturbing the homeostasis in various parts of the masticatory mechanism. The structures possessing the least resistance will manifest pathologic phenomena just as soon as their physiologic limit of tolerance has been exceeded.

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CONDITIONS WHICH MAY INFLUENCE THE CHOICE OF PARTIAL OR COMPLETE DENTURE SERVICE

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THE CHOICE OF PROSTHETIC service which is to be recommended in some partially edentulous situations may present a true dilemma. It may be expected that in certain borderline cases there will be a difference of opinion as to the prosthetic procedure indicated. As we study the many factors involved, and realize the complexity which may be presented, it may seem surprising that complete agreement is ever reached.

The arrival at the best solution of a partially edentulous situation is many times further deterred by strong opinions which one party to the decision-making process may hold—this is the patient himself. To some individuals the verdict, "You must now have complete dentures," is regarded as little short of being told that he or she already is an old man or woman. However wrong the conception, there is, unfortunately, a popular tendency to associate the need for complete dentures with Shakespeare's famous description of the seventh and last state of human life—"sans teeth, sans hair, sans everything." And because of this "old age" implication, to recommend that all remaining teeth be extracted is a certain formula for achieving immediate unpopularity with most patients who may have sought advice regarding the replacement of only some teeth. On one subject, regardless of their chronologic ages, most persons can be expected to react quite vocally and with more or less indignation—"I am not old."

The election of a prosthodontic service certainly should be decided on considerations other than just that of patient preference. Even when patient preference is to be intentionally overweighted, as when the patient is emotionally unbalanced about the prospect of losing his remaining teeth, there should be an honest effort to rationally evaluate *all other* conditions which may affect the chances of procuring the best prosthetic solution. Furthermore, it should be remembered that what may be considered best for the immediate present or near future may not be the most beneficial solution throughout the expected life span of the patient in question. No prosthesis which hastens the destruction of the remaining oral structures through overloading can be rated as good dental rehabilitation.

It is certain, also, that the relative importance of each factor to be considered will vary greatly from one patient to another. Therefore, it is perhaps point-

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less to attempt the consideration of these determining conditions in any definite sequence which might be dictated by urgency. A condition which may indicate strongly the election of a certain prosthetic procedure in one instance might receive no more than passing consideration in another. This fact must be kept in mind throughout a discussion of the comparative merits of the following factors with which we may meet most commonly.

PROBABLE EXPECTANCY OF THE REMAINING TEETH

A very common question, particularly from patients of lower income brackets, is, "Doctor, are my remaining teeth worth saving?" This pointed inquiry carries an economic implication which must be given consideration. For at least some, and at times many patients, this may be the most determinative factor. The necessary treatment, and restoration of remaining teeth often may entail more of an economic burden than the prosthetic service which is to follow. When this is the situation, and where the oral conditions also are such that only a short period of service can be expected, then it obviously cannot be the selected treatment for the patient who occupies a critical economic status.

In this connection, however, we should avoid the position of being the judge in the matter of a patient's economic limitation. It is recommended that the selected plan of oral rehabilitation be outlined to the patient, using visual aids to emphasize carefully the advantages of this preferred reconstruction program. If there is sufficient merit to this preferred plan, the patient may deem it to his advantage to approve it even when considerable economic strain may be involved. It seems to the author that the matter of economics is no less an ugly fact of life in dental service than in other activities. Here, as in other situations, it must be met squarely and discussed honestly. When there is any possible opportunity for its financial solution, the most ideal prosthetic procedure should be chosen. When another *less complicated* method can be suggested, that also effects a reduction of the service cost, then it too should be explained. If there are inherent disadvantages connected with the second method, they should be stated plainly. It is then for the patient to make a choice based on the relative merits of the proposed plans as viewed in relationship to his economic limitations. In attempting to resolve the economic phase, the fact should be stressed in discussions with the patient that the *least initial cost is not necessarily most economical* in the end.

It should be emphasized that when the estimated functioning of the proposed complete denture is expected to be less than normal, for whatever reason, then it would be the procedure of choice to retain and restore the remaining teeth. Under such circumstances, this should be urged regardless of the greater resulting economic pressure, and even when the partial denture may be expected to serve only for a relatively short time.

RIDGE ATROPHY FROM DISUSE

When teeth have been missing from the dental arch for a long period, the residual ridge will not have been maintained at its maximum of supporting capability.[8,10] On a basis of clinical observation, disuse atrophy seems to be espe-

cially evident in the edentulous ridge from which all posterior teeth have been lost (Fig. 1). Supported by residual bone in this condition, a partial denture may be expected to require even more meticulous maintenance service than usually is needed. When cooperation in having the appliance adequately reconditioned cannot be expected from the patient, this may be a most logical reason for employing complete denture service at once. To be sure there also will be settling of the complete denture in areas of previous ridge disuse, but at least there will not be the severe leverage forces developed as seen when a partial denture is worn, after it has lost ridge support, by a careless patient.

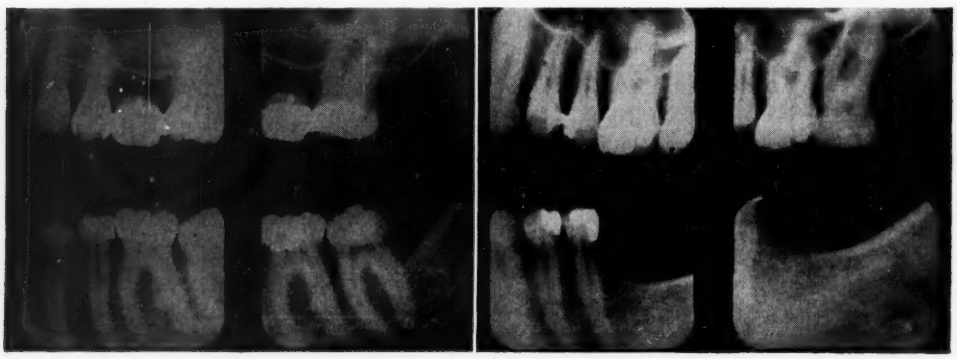

Fig. 1.—Roentgenograms of the same mouth. *Left,* the maxillary bicuspid-molar area shows an excellent alveolar bone response where a tooth-borne prosthesis has been supported for about fifteen years. *Right,* the mandibular molar area of the opposite side has been edentulous for approximately the same length of time. Note the extensive bone loss, because of disuse, in a mouth in which the bone has shown the ability to carry more than the normal work-loads very satisfactorily.

TEMPORARY PARTIAL DENTURE SERVICE

More attention should be directed toward reconditioning the edentulous ridge before having the patient undertake his complete denture experience. When there has been a long period of disuse in part of a dental arch, it is recommended that we institute exercise of these ridges before they are asked to support a functional load. This may be done in different ways, usually but not necessarily, requiring a temporary partial denture. Tissue stimulation may be given by the patient. He may massage the edentulous ridge area frequently and vigorously by finger pressure, or an occluding block of soft acrylic resin (Fig. 2) may be made to fit the ridge and the opposing teeth, and the patient may occlude against this to introduce stimuli which simulate those resulting from functional forces.[7]

These forms of stimulation may be expected to encourage bone reorganization but without the danger of exceeding the limits of the reduced tissue tolerance which has resulted from disuse of the area. If a partial denture is constructed for this type of ridge without previously being conditioned, great care must be exercised to avoid overwork in the early months of its usage. This may be accomplished by leaving the posterior teeth off of the partial denture for a period of a few months, using only finger pressure on the base at regular intervals to simulate the stimuli

which would have been induced by occlusal contact. Or, instead of teeth, a very narrow occlusal table of resin may be used. This limits the total load to which the ridge is subjected. If soft resin is used for the occluding surface, the possibility of overload is further reduced. This procedure is especially effective in limiting the stress which may occur in spasms of bruxism. In producing these resin occluding blocks for exercise, it should be noted that balanced occlusion is quite as necessary as at any other time.

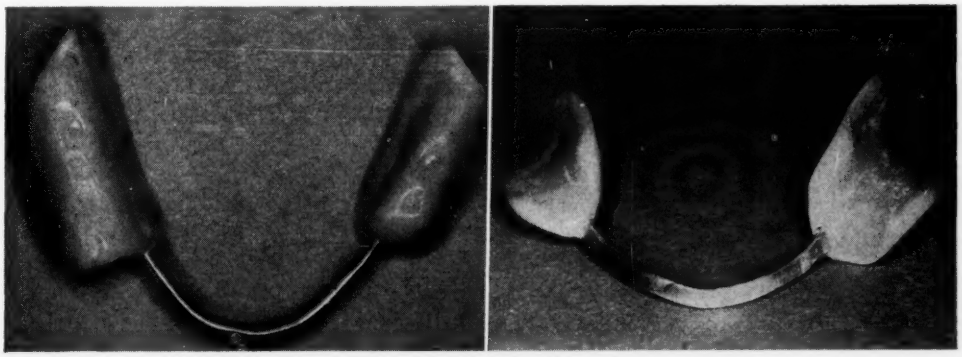

Fig. 2.—An *exercise* prosthesis to be used temporarily for reconditioning a foundation area which has undergone disuse atrophy (osteoporosis). *Right,* the tissue surfaces of bases made to functional form and of maximum area. *Left,* the occlusion rims of soft acrylic resin. The right and left bases are united with a temporary major connector made of wrought lingual bar material. By biting on the soft resin (or by biting a finger placed on the occlusion rim) in two or three periods of daily exercise, a stimulation may be expected to cause a gradual improvement of the alveolar structure where a full occlusal load would cause a resorptive change.

BONE REORGANIZATION

Under this method of bone reconditioning, the edentulous ridge may be expected to undergo a process of reorganization which will prepare it to accept a reasonable occlusal load, at a later time, with much less or no resorptive change at all. Such bone reorganization includes not only the strengthening of the individual trabeculae, but also may include the formation of an altered trabecular pattern in response to the reception of masticatory forces in a manner entirely different. When teeth were present, the occlusal forces were received "as traction to the alveolar bone proper (lamina dura) via the principal fibers of the periodontal membrane."[11] When lost teeth are replaced, the occlusal forceloads are transmitted through the appliance base, and will be received by the foundation structures as a direct vertical impact.

One argument in favor of such exercise stimuli being originated from a balanced occlusal surface, rather than by massage, is that the induced stimuli will then be received by the ridge surface in the same direction that the lines of force will later be directed from the occlusal surfaces of the supplied teeth. Hence, any new pattern of trabecular growth will be best arranged to receive the new occlusal forces with the least chance of overload. Three advantages may be expected to accrue from such a program of ridge reconditioning prior to placement of partial or complete dentures: (1) The resorptive loss of ridge structures will be minimal. (2) In the case of complete dentures, there will be least disturbance of occlusal bal-

ance as a result of an uneven change in the vertical height of the residual ridge. Such vertical loss is greater in the area of previous disuse, and least where the teeth had been under functional workloads until the time of extraction. This uneven resorptive change may be at least one explanation of why properly balanced occlusion may change to one of imbalance within a few months after immediate dentures have been placed. (3) In the case of partial denture placement after ridge reconditioning, there will be the least chance of the base becoming unstable as a result of vertical resorptive change. The author is convinced that pre-restorative reconditioning of the partially edentulous arch offers a very encouraging possibility of keeping the stress-loads induced by partial or complete denture prosthesis much more safely within the limits of tissue tolerance. Also, the psychophysiologic advantages which can be expected to accrue from avoiding the soreness resulting from areas of local trauma will greatly alleviate the rugged early days of denture experience.

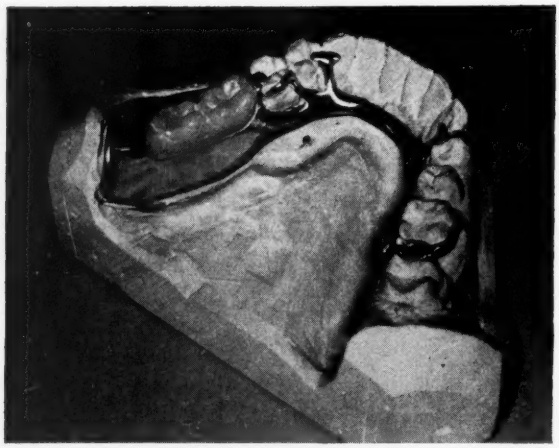

Fig. 3.—The extension-base partial denture is a potential lever. If the free-end base is not maintained in a stable relationship with the subjacent foundation structures, certain movements can occur. These can be visualized as vertical (toward and away from the ridge), horizontal (lateral movement of the free-end of the base), and a rotational movement of the appliance over the ridge crest and the occlusal rest support. Through such appliance movement, the occlusal forceload will be magnified in direct ratio to the length of the occlusal table, then transmitted to the area of the supporting abutment.

LOWERED TISSUE TOLERANCE

Another important factor to be given consideration in deciding the prosthetic service of choice is lowered tissue tolerance. An evident poor physical condition, or a continuing history of physical disability is indicative of a lowered tissue tolerance. This would be an added contraindication for any elaborate restoration of the remaining teeth to be followed by partial denture service. If the tissue tolerance is too low to expect good results from partial denture prosthesis, it logically may be asked, how the same low tolerance can be expected to result in any better complete denture service? The reason is very simple. Since the complete denture is supported only by the foundation structures, the trauma resulting from resorptive change cannot begin to equal that resulting from the stresses

generated by movement of an unstable partial denture supported by both teeth and ridge structures. Acting as a lever (Fig. 3) the partial denture will magnify the occlusal force-load.[1] If the patient's tissue tolerance is low, this exaggerated stress-load, when received by the structures supporting the abutment teeth, will be much beyond their limit of tolerance. The unstable partial denture is a much greater menace to the structures supporting it than is the unstable complete denture.

ALVEOLAR ATROPHY SUSCEPTIBILITY

Consideration should be directed to an analysis of the patient's probable ability to maintain a good alveolar support. It is upon this metabolic factor that much of his success with a prosthesis will depend. The person who cannot replace bone elements as rapidly as they are used will have little chance of maintaining the remaining teeth when some of them are used in the supplementary capacity of abutments for a partial denture. So many different factors are concerned with the maintenance of normal bone metabolism that correction of a failure in this direction is often quite difficult. Evidence of a generalized bone loss of the "diffuse atrophy"[9] type is indeed a sign indicating a poor prognosis for partial denture service.

A dependable method of measuring probable bone tolerance of induced work-loads in the areas of remaining teeth can be based on roentgenographic studies. Areas of alveolar process which have supported teeth that are known to have received more than a normal stress-load can be used as an index of that patient's probable bone tolerance.[2] If, in an area of increased work, there has been a good response and the bone has been maintained normally, then there is good reason to expect that it may accept a reasonably increased work-load without damage (Fig. 1). If, on the other hand, the bone of the index areas shows signs of retrogressive change (Fig. 4), the addition of more work may be expected to induce a still more rapid deterioration ending in abutment failure. As examples of such index areas (Figs. 5, 1), one may cite the tooth which has served previously as an abutment; the tooth which is tipped out of normal vertical alignment, so that it magnifies, through leverage, the work-load which is received on its contacting surfaces; and the tooth located adjacent to an edentulous area and which has been receiving some added functional load formerly carried by the teeth now missing. If, in such index areas, the patient shows a good ability to replace bone elements as they are used, the prospects for restoring the missing teeth by use of the free-end partial denture is excellent. But where there is extensive bone failure in such areas, the chance of anything but a *temporary service* is not to be expected.

PREVIOUS LOSS OF TOOTH SUPPORT

A definite relationship is known to exist between the amount of previous bone loss at the cervical crest and the ability of a tooth showing such loss of support to assume added work-loads. The amount of cervical bone loss has a pertinent bearing on the decision to retain or extract a tooth. When there is cervical bone loss, the *extra-osseous* portion of a tooth is increased, and the *intra-osseous* segment

of the root becomes shortened (Fig. 6). In this situation, the occlusal load is augmented by the unfavorable leverage ratio which follows. *Even when there is no periodontal involvement,* the tooth may fail because the tolerance of the supporting bone structure may be constantly exceeded. When too much vertical loss

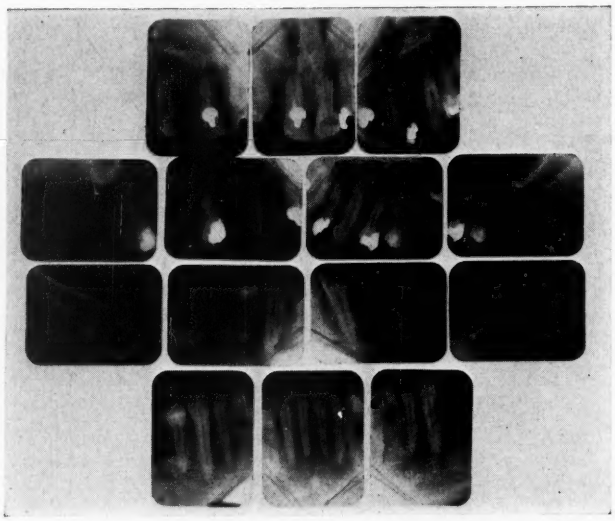

Fig. 4.—Evidence of failure to maintain the alveolar structures throughout both dental arches. Since alveolar bone furnishes the foundation for denture support, generalized evidence of susceptibility to extensive alveolar atrophy is an indication that the prosthetic result will be poor. To obtain a relatively satisfactory prosthesis will not only tax the skill of the prosthodontist but will test the tolerance of the patient as well.

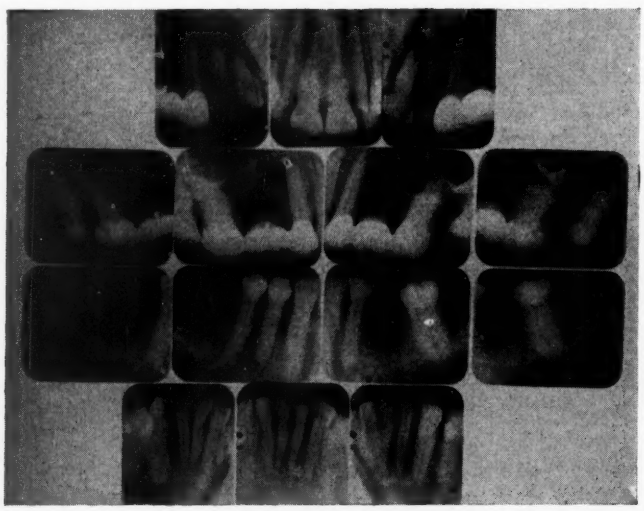

Fig. 5.—Examples of "index areas." They are key areas in the evaluation of a patient's probable alveolar bone resistance to added work-loads. The maxillary bicuspid and molar teeth have been doing the extra work of serving as abutments for bridges; the lower molar is inclined, placing added strain upon the mesial wall of the supporting bone; the lower bicuspids have had more than normal work-loads because of the absence (apparently for many years) of the other posterior teeth. There are index areas also in Fig. 1 which show remarkably fine bone reaction to added functional strains.

of tooth-supporting bone has occurred, the tooth becomes questionable as an abutment for the partial denture which is expected to last for more than a temporary service. One should not become overly optimistic in making this evaluation by the fact that the tooth still is firm. The simple fact that no excess mobility exists, does not eliminate the possibility that the supporting bone is already being overloaded, or that it would be when asked to serve as an abutment.

Another condition to be noted in this connection is the effect of root taper. When the abutment root shows a marked taper (Fig. 7), the rate of vertical loss may be expected to accelerate because the *supporting area so rapidly decreases.* In such circumstances, we find the work-load becoming increasingly augmented as the extra-osseous work arm of the lever lengthens, while the area of intra-osseous units of supporting surface is becoming rapidly reduced. A formula of *more and more work on less and less supporting bone* is one that can lead quickly to failure.

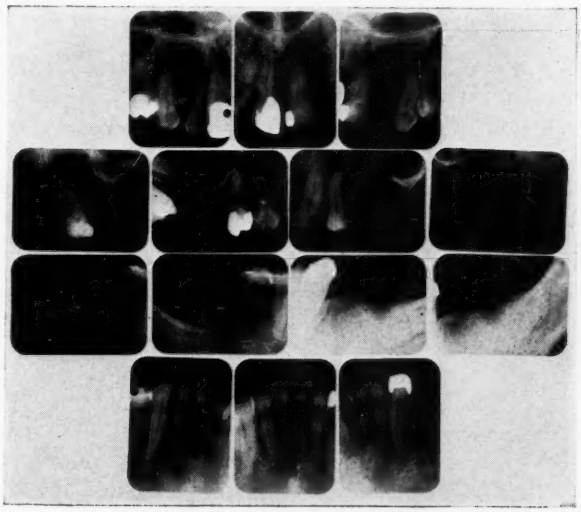

Fig. 6.—The lower bicuspid teeth adjacent to the edentulous area show excessive loss of supporting bone. The work-load received by these teeth will be greatly magnified by the unfavorable leverage situation now existing between the supported and the unsupported segments of these roots. Compare these bicuspids to the same teeth shown in Fig. 1 *(Right).* There is good reason to expect the abutment in Fig. 1 to give excellent service while those in Fig. 6 might fail very quickly if used for abutment support.

It should be noted that quite frequently the tooth available for abutment use in partial denture service will be the mandibular bicuspid. This tooth usually presents a round, single, and tapered root. Being round, it can least resist the destructive stress of twisting forces when a free-end appliance moves laterally. Being tapered, it will be most unfavorably affected when a cervical loss of supporting bone has occurred. Thus, the tooth most frequently used as a partial denture abutment also may be the least suited to provide an adequately stable support for a service period of reasonable length. Abutment root form, and the status of its support may well be critical factors in determining the election or rejection of partial denture service.

NUMBER AND LOCATION OF REMAINING TEETH

Since it is obviously impossible to discuss this factor in an adequate manner in this limited article, only generalities can be stated. Of significant importance in the decision to retain some remaining teeth in a dental arch is their *location.* This is perhaps more important than the number of those remaining. However, with each decrease in the number of teeth remaining, the induced work-load on the supporting structures increases it two ways. In the first place, the more teeth replaced, the longer becomes the occlusal table on which functional stress may be developed (Fig. 8). Second, when the prosthesis is of the free-end, extension type, this generated work-load is further increased because the appliance may act as a lever. Thus, fewer and fewer teeth must accept more and more stress as their number decreases (Fig. 8). In general then, the service life of the partial denture may be said to decrease with the reduction in the number of teeth remaining.

Another important fact in this connection, relates to problems of design. As the extension appliance is increased in length, the difficulty of preventing vertical movement of its free-end base becomes greater. Again an adverse leverage factor is noted, with the indirect-retainer, which acts as a counter-lever, becoming increasingly less effective as it is shortened, because the fulcrum line has moved anteriorly. This reaches a maximum degree in the situation where only a few anterior teeth remain (Fig. 8). If such a Class I partial denture is for the maxillary arch, to other forces causing its vertical movement away from the supporting ridge that of gravity must be added. Hence, in the maxillary arch, the problem of retaining a few anterior teeth is accompanied by greater hazard.

That their *location* is of greater importance than the *number* of teeth remaining, can be cited in a situation where the six anterior teeth remain, as compared to another (Kennedy) Class I case, where only the right and left second bicuspids and cuspids remain. By using a fixed bridge prosthesis to supply the right and left first bicuspids and the four incisors, a very effective cross-arch splinting of these four remaining teeth is accomplished. A Class I removable partial denture for this arch will be much better stabilized for a second reason. The indirect retainer is much longer when the second bicuspid teeth rather than the cuspids serve as abutments. Here, four remaining teeth allow a much greater reduction of the induced work-loads than where six teeth remain from right cuspid to left cuspid. This example illustrates the urgency of analyzing the strategic importance of each remaining tooth critically before agreeing to its extraction. When so few teeth remain in a dental arch that the induced stress-load will exceed the tolerance of the supporting structures, the only excuse for using a partial denture is to provide a strictly *temporary or short-time service.* Nevertheless, it may be advisable where the complete denture stability is sure to be less than average, and more particularly with temperamentally unfavorable patients, to retain a few teeth to assist in stabilization. Thus, the trying period of early adjustment of the patient to dentures is made easier. While this is sound prosthodontic procedure, it should be presented to the patient for exactly what it is—*a treatment denture.* It is *to be used only temporarily* because, in such cases, partial denture service

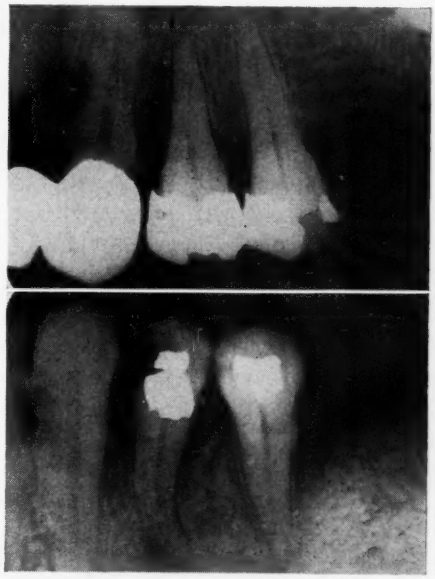

Fig. 7.—Note the extreme root taper in the bicuspid teeth. The loss of units of surface support will be sharply accelerated as the vertical level of the alveolar bone is reduced. Hence, the vertical loss of supporting alveolus wall is much more critical when the abutment root also shows severe taper. This is a very important point in evaluating a tooth for prospective abutment service.

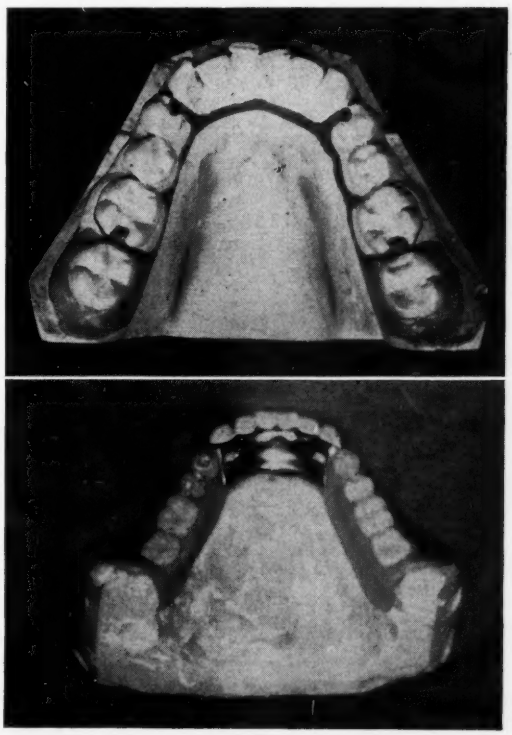

Fig. 8.—The design on the upper cast shows the Class I (Kennedy) situation replacing only the lower second molars. The opposite extreme, in a Class I condition, is seen in the lower partial denture with only the six anterior teeth remaining. This is a graphic illustration of the increase of induced work-loads and the reduced supporting structures which occur as posterior teeth are successively lost.

already has been adjudged as impossible. If this auxiliary service (utilizing a treatment denture) is dignified by proper presentation a much happier patient-relationship will be attained.

SPLINTING OF WEAKENED TEETH

It has been pointed out that when there has been previous loss of supporting alveolar bone, the employment of such weakened teeth for abutment use may be debatable. In this circumstance, or where unfavorable root form exists, there still is a possibility of retaining the teeth with reasonable assurance of gaining satisfactory service from them as partial denture abutments. However, this possibility is contingent upon two conditions: the presence of other teeth suitable for splinting, and the economic latitude which permits this complicated and rather costly service.

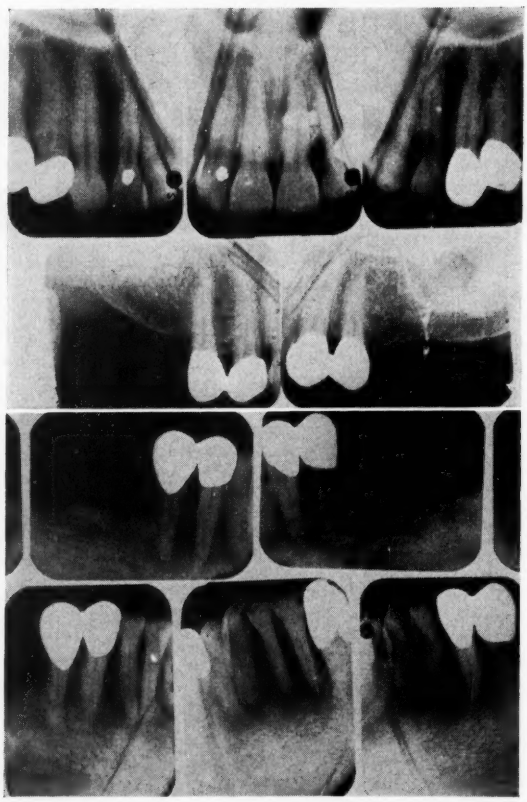

Fig. 9.—Several instances where the splinting of adjacent teeth is used to strengthen weak teeth to better their chance of serving satisfactorily as abutments.

The splinting of adjacent teeth, to produce the effect of a multirooted abutment, not only divides the work-load over a greater area of supporting alveolar wall but, equally important, a counterleverage effect, such as is found in a multirooted tooth, is gained. The union of separated roots tends to offset the stresses of torque and tilting leverage (Fig. 9). By lessening the load upon the alveolar

structures in these ways, a reorganization and improvement of the bone has been shown to occur.[3, 5] In extreme cases, the remaining teeth may be urgently needed, even though they show serious bone loss. For example, all of the anterior teeth may be restored by three-quarter or complete crowns in order to permit their attachment to each other and to the cuspids and bicuspids of each side, if these are present.[6] The possibility of achieving a partial denture result of acceptable longevity may hinge upon the presence of teeth which can be splinted, as against a situation where this cannot be accomplished. No more effective way of reducing induced stress loads has been demonstrated than that of multiple union of teeth by splinting (Fig. 10).[4]

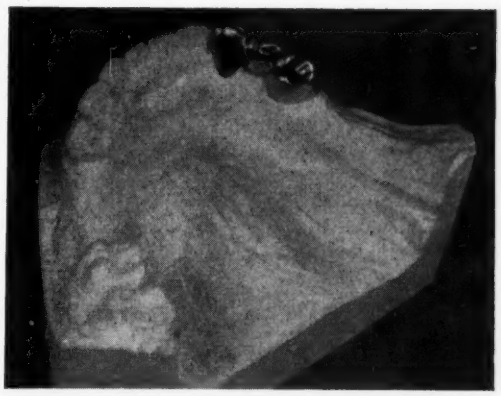

Fig. 10.—The second bicuspid has been left with an edentulous condition both anterior and posterior to it. If it must serve as an abutment for an extension Class II (Kennedy) partial denture, the use of a bridge to replace the missing bicuspid provides an ideal splinting action. This employment of a splint is one of the most essential of all.[4]

UNFAVORABLE RIDGE FORM

Poor residual ridge form is usually a condition which may be said to indicate the *retention* of remaining teeth in order to achieve better stabilization of the prosthesis. A flat ridge provides little resistance to lateral movement of an appliance. An extremely narrow ridge with vertical lateral sides lessens interfacial surface tension, thus, reducing the retentive quality of the complete denture. Both of these conditions are more often encountered in the mandibular arch where complete denture retention is minimal even when the ridge form is normal.

Hence, the decision to use partial denture treatment may be the procedure of choice, solely on a basis of the residual ridge form being objectionable. This decision often is simply one of accepting the least objectionable of the choices presented, and is made even when the remaining teeth are unfavorable for one or more of the variety of reasons previously enumerated. Under such conditions, it is especially wise that the situation be carefully explained to and understood by the patient; that the need for complete cooperation by him in properly maintaining such an appliance is doubly urgent; and that its service expectancy is greatly reduced.

CARIES SUSCEPTIBILITY

A marked dental caries susceptibility, as established by salivary tests which determine bacterial counts rather than the number of carious lesions, may be the deciding factor in reaching an opinion favoring the use of complete dentures. This is an especially important consideration when the patient is disinterested in seriously attempting to control the conditions which are known to favor dental caries. It would seem worse than useless to restore numerous carious teeth in a program of mouth preparation, followed by partial denture treatment, only to have all of these efforts nullified by the recurrence of caries as a result of patient disinterest in control measures.

PROBABLE PATIENT COOPERATION

It is important to recognize the absolute need of adequate patient cooperation in maintaining the partial denture in the best possible functioning condition. This is especially true of the extension type of removable partial denture. Loss of base support following resorptive change transforms this prosthesis into a destructive lever, magnifying the work-load as the appliance transmits these stresses to the supporting structures of the abutment area. A partial denture treatment is doomed to early failure unless the patient is really enthusiastic about retaining the remaining teeth. He must be willing to spend time in proper home care to assure oral cleanliness and stimulation of the gingival tissues. He must be punctual in having regular and frequent inspections, roentgenographic examinations, and any needed adjustments, alterations or reconstruction of the partial denture. No patient who does not have this cooperative attitude can hope to receive a successful partial denture service. Without this cooperation, the choice of complete dentures might just as well be made at once before the oral structures have been damaged by improper use of the partial denture.

EXCEPTIONAL SITUATIONS WHICH INFLUENCE PROSTHODONTIC CHOICE

There will be situations encountered in which the indicated prosthetic treatment must temporarily be delayed for social or occupational reasons. The transition from natural to prosthetic dentition, even under ideal conditions, requires a psychophysiologic adjustment which may be quite an effort for some individuals. It will be wise, where possible, to avoid periods of intense pressure from vocational or social demands for the rendering of complete denture service. This is another logical reason for the expenditure of much effort to retain some teeth, and to provide a *treatment* or temporary partial denture service. As an example, one might cite the instance of the important business executive or the talented symphony artist who has only a few years of active service before retirement. His prosthetic transition to complete dentures might be made so very much more easily at a later period of reduced tension. This would be no less true of the busy woman who presently faces important social activities as against a later period of reduced demands. Too frequently, the prosthodontist considers his patient only as a dental patient, not as an *individual* needing prosthetic service. The importance of this factor of social or vocational status may be emphasized by citing the opposite

extreme—that of the laborer to whom it might not make the slightest difference whether a complete denture service was to be rendered at one time or another.

A word of caution also should be directed to a situation which is very rarely encountered, but which may have tragic consequences for both dentist and patient. This is the instance where x-ray or radium therapy may be required in the region of remaining teeth. The incidence of osteomyelitis when extractions follow such therapy is so great, that the extraction of all teeth is recommended by oral surgeons before it is given. When this procedure has not been followed, it is imperative that extreme efforts be made to preserve the remaining teeth in the best possible state of function and comfort in order to avoid extractions later. Often the use of a partial denture in such cases is difficult, sometimes impossible. To avoid the necessity of a person having to exist with only a few remaining teeth and with inadequate dental function, it would seem best to extract all teeth of the involved area before x-ray or radium therapy is to be used. Thus, the choice of prosthodontic service may be dictated by a physical condition not directly related to the oral structures which support the appliance. This would emphasize the wisdom of obtaining a medical history before ordering the extraction of remaining teeth.

SUMMARY

A goodly number of varying conditions comprise the factors to be evaluated in making the frequent choice between partial and complete denture service. Since many situations are border line in character, there are honest differences of opinion to be expected. It is urged that in making such analyses, that the best interests of the patient be considered, not on a basis of immediacy, but rather on what will be of most benefit for him throughout his expected life span. In view of the greatly increased life expectancy of the present age, this altered viewpoint in prosthodontics is urgently needed. This division of dentistry has geriatric problems of great importance.

The probable length of service to be had from the remaining teeth must be estimated in terms of the cost of their reconditioning and maintenance. Caries susceptibility, and the attitude of the patient toward dental caries control, as well as his economic status, must be considered in this evaluation. If the condition of the remaining teeth has been further impaired by the cervical loss of supporting alveolar bone, another economic complication has been added. Because of the unfavorable leverage which follows such bone loss, the greatly increased work-load on the reduced surface of the supporting alveolar walls is such that tissue tolerance will be exceeded unless splinting of adjacent teeth is accomplished. The value of this procedure is well established, but the fact remains that it entails arduous and time-consuming effort, and, therefore, for many it will present financial difficulty. Let us face the facts. Regardless of the need, or the patient's great desire for a partial denture service, and not withstanding every consideration which an overly generous prosthodontist can make, there will be those cases in which a *good* partial denture program is economically impossible.

However, when this obstacle does not exist, it is urged that every effort be made to provide a partial denture service of greater longevity. The marvelous

advancement made in recent years in endodontics and periodontics is certain to result in an increasing number of partially endentulous mouths. Teeth which were routinely lost yesteryear are being saved today. Still more will be salvaged tomorrow. The vigorous attempt to indoctrinate a physiologic approach to the rendering of partial denture service has brought about a marked improvement in partial denture design and fabrication. Under favorable conditions, the partial denture need not be a "stop-gap" service, nor need it be a "stepping stone" to the complete denture. Certainly, some partial denture treatment will fail. It is inevitable that some patients will decline physically. But this group of failures should not include those partial dentures which were from the beginning intended only to be *temporary. The author urges that these appliances be called "treatment" dentures.* They are to be used only where conditions contraindicate the attempt to retain the remaining teeth. The patient should be impressed with the facts that the "treatment" denture is of great value but that it is to be *temporary.*

An increased effort toward the conditioning of the edentulous ridge structure should be made before the residual ridge is used to support a prosthesis, whether partial or complete. This is going to be the next great step forward in prosthodontics. It will be a further step toward achieving DeVan's ideal, "the preservation of that which remains, rather than meticulous replacement of that which is missing."

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STRESS ANALYSIS IN DISTAL EXTENSION PARTIAL DENTURES

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PARTIAL DENTURES ARE GENERALLY considered to contribute to trauma of the periodontal tissues of abutment teeth. This is particularly true of distal extension partial dentures. This is due to the fact that too often little consideration is given to the stress tolerance of the supporting anatomic structures when a partial denture is designed and planned.

Teeth are equipped by nature to withstand stresses applied in the direction of their long axes. Excessive stresses which tend to tilt or rotate teeth in their sockets will result ultimately in damage to the periodontal structures. It follows that lateral and rotational stresses on the abutment teeth, must either be avoided or reciprocated. It is the dentist's responsibility to design, construct, and adjust partial dentures so that they will function within the limits of physiologic tissue tolerance.

When planning the design of a denture, its behavior during function must be considered, since the denture base always moves with the supporting mucosa. To consider stabilization and retention of the appliance on the cast alone does not suffice. The load, as received by the artificial teeth during mastication, is transmitted through the denture base and the various parts of the clasp to the contacted anatomic structures. This results in two types of stresses:

1. *Unaltered stresses:* These are stresses which are transmitted by the partial denture to the supporting anatomic structures in the same direction as received.

2. *Altered stresses:* These are altered in magnitude and direction by the contacts established between the different parts of the appliance and the anatomic structures.

The magnitude and direction of stresses to which the supporting structures will be subjected depend upon the type of partial denture, as well as upon the design of its parts in relation to the anatomic form of the supporting structures. For example, the denture base of a distal extension partial denture, constructed without rests or clasps, will move freely tissueward when a vertical masticatory stress is applied (Fig. 1,*A*). The amount of this movement will be determined by the displaceability of the underlying mucosa. The vertical stresses will be transmitted to the underlying structures in the same direction as received by the partial denture base and will be distributed over the entire area of bony support. This is an example of unaltered stresses.

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If this same partial denture is constructed with occlusal rests on the adjacent abutment teeth the situation will be radically changed (Fig. 1,*B*). When a masticatory load is then applied to the denture base, the rest will act as a definite stop which will prevent the part of the base near the abutment teeth from transmitting the load to the underlying anatomic structures. The distal end of the base, being able to move freely, will transmit the major part of the masticatory load to that part of the bone. The denture will not transmit the stresses *evenly* to the supporting bone, but only to the abutment teeth and that part of the bone which underlies the distal end of the denture base. If a clasp arm were added to this partial denture and so designed as to engage a mesiobuccal undercut on the abutment tooth, this clasp arm

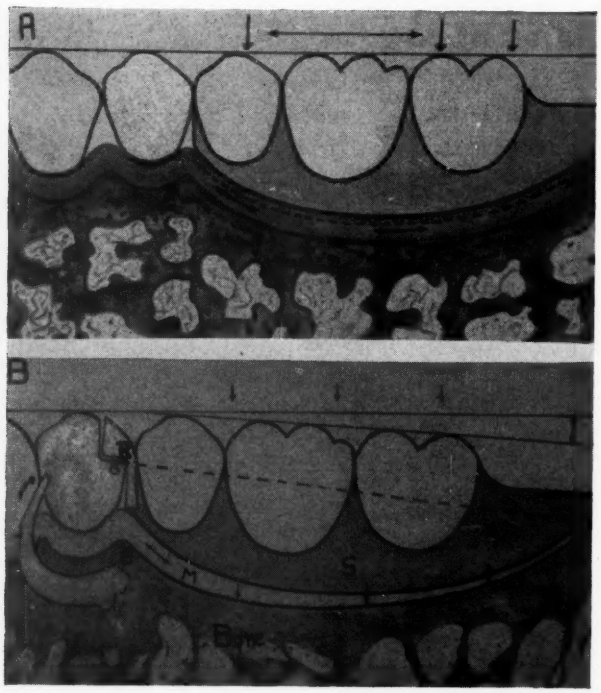

Fig. 1.—*A*, The denture base without an occlusal rest. *B*, The occlusal rest *R* prevents the stresses from being transmitted to the total alveolar support.

would introduce additional stresses by moving in an opposite direction to the denture base, with the rest as a fulcrum of rotation. While clasps and rests are generally thought to counteract the stresses exerted upon the partial denture, they may themselves cause altered stresses to the supporting structures which can be more destructive in effect than the original masticatory force. Since an occlusal load always causes a displacement of the mucosa and since this mucosa cannot be permanently displaced but is consistently trying to return to its passive state, a definite amount of movement of the partial denture base will have to be recognized and allowed for in the clasp design.

VERTICAL MOVEMENT OF THE DENTURE BASE

It appears, therefore, that the primary movement of the partial denture base in response to stresses which tend to seat it must be considered and controlled before a proper analysis of the resulting stresses to the abutment teeth can be made. The amount of the load to the basal seat depends upon the amount of the masticatory force as received by the artificial teeth, and on an optimum distribution of this load to the supporting anatomic structures.

The amount of the masticatory force on the denture base is a resultant of the patient's muscle power, and the size and number of artificial teeth used. While the patient's muscle power is not under the dentist's control, the resultant force to the denture base can be reduced by using teeth which are narrow buccolingually, and by modifying their cuspal inclinations as suggested by DeVan.[1] In turn, the stresses on the structures underlying the base can be reduced by maximum coverage of the supporting structures as suggested for complete denture construction by Boucher.[2]

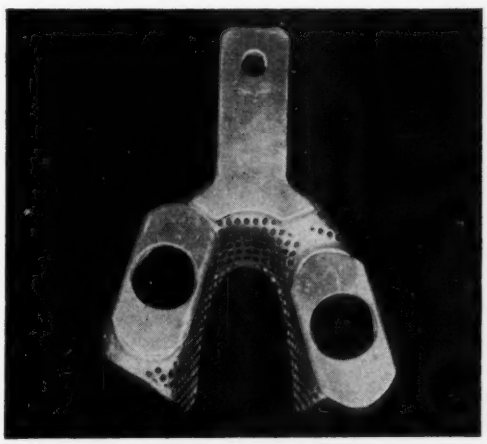

Fig. 2.—The double impression tray used in the author's technique. The finger opening in the slide can be positioned depending on the location of the edentulous area. A similar tray designed to accommodate plaster can be used if the abutment restorations are to be transferred to the master cast.

It must be remembered, however, that an equal distribution of the masticatory load to the supporting teeth and the alveolar ridges is not possible unless the occlusal rest has been eliminated as a fulcrum point around which the denture base rotates during function. In a previous article,[3] a technique of impression making was suggested to avoid this fulcrum action around the occlusal rest (Fig. 2). Three definite requirements were stated which are considered necessary for obtaining optimum load distribution on the supporting structures:

1. The tissue surface of the denture base should be a negative reproduction of the undistorted anatomic surface of the mucosa.

2. The masticatory load should be distributed between the ridge and the abutment teeth in the functioning position of the denture base, and cannot be left to be carried by the residual ridge alone.

3. The denture base should be related to the metal frame in such a way as to be similar to the relationship existing between the supporting teeth and the sup-

porting mucosa when the latter is in a state of maximum displacement under the denture base.

In a partial denture constructed from an impression which fulfills these requirements, the occlusal rest of the partial denture should be in its seated position on the abutment tooth when the partial denture base is under a masticatory load, and is seated on the displaced mucosa (Fig. 3,*A*). The residual bone will then carry its share of the load throughout the full extent of the basal seat, and will be aided by the abutment teeth in sustaining this load. Since the tissue surface of the denture base reflects the undistorted anatomy of the mucosa at rest, the amount of tissue displacement under a masticatory load will be kept to a minimum. Upon release of the masticatory stress, the denture base will move occlusally with the rebounding mucosa, and the occlusal rest will lift slightly off the floor of the rest seat on the abutment tooth (Fig. 3,*B*). This slight lifting up of the occlusal rest is essential, since, when a masticatory load is again applied, the denture base will be able to move evenly tissueward without interference from the occlusal rest until the tissue is displaced, and the residual bone under the denture base carries the load. At this time, the recessed occlusal rest will contact the floor of the rest seat, and the tooth will take up some of the masticatory stresses. Only a small amount of load is necessary to displace the mucosa, almost as much as it can be displaced by a maximum load. Therefore, the occlusal rest will arrive in its final position in the rest seat at an early stage of the chewing stroke so that, when the full masticatory load is applied to the denture, the stresses will be distributed between the abutment teeth and the entire bony support.

This is a method of controlled stress breaking between the abutment teeth and the residual ridge, in which both are required to contribute their share of denture support. The initial movement of the denture base will be even, to and from the supporting alveolar bone, rather than a tilting movement around the occlusal rest.

DENTURE BASE ROTATION

If the artificial teeth of a denture are set buccal to the crest of the alveolar ridge, a rotation of the denture base will occur as a result of vertical as well as lateral stresses on these teeth (Fig. 4). The axis of rotation of this movement lies under the denture base of the working side, and follows the crest of the residual ridge. With a bolus of food interposed, the denture base on the working side will move toward the mucosa. At the same time, the denture base on the balancing side will lift up until toward the end of the chewing stroke when the opposing teeth begin to occlude and both bases will be seated evenly. Simultaneously, the clasp on the balancing side will move with the denture base in an occlusal direction and, if the abutment tooth is grasped rigidly, it will tend to be pulled out of its socket by the clasp with each chewing stroke.

Denture base rotation can be reduced by setting the artificial teeth into an area between the crest of the residual ridge and an imaginary line projected vertically upward from the mylohyoid ridge, or by reshaping the teeth as suggested by Pleasure.[4] Furthermore, clasps should be so designed and adjusted that they will not grip the teeth tightly, and so that a small amount of gingivo-occlusal movement is possible before the clasp engages an undercut.

CLASP ACTION

Clasp planning and design must be based upon the type of stresses that clasps will exert upon the abutment teeth. These stresses, in turn, will depend on the direction of movement of the denture base. If this movement is vertical, that is,

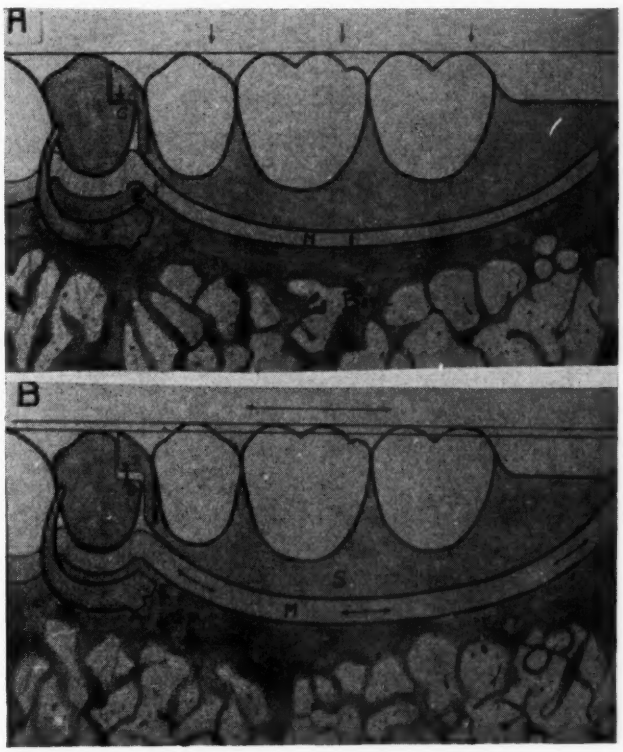

Fig. 3.—*A*, The denture base is under a masticatory load. The mucosa is evenly displaced. The stresses are distributed between the entire bony support and the abutment tooth through the rest. *B*, The mucosa has rebounded. The occlusal rest has moved occlusally with the denture base. The floor of the rest seat will not now act as a fulcrum.

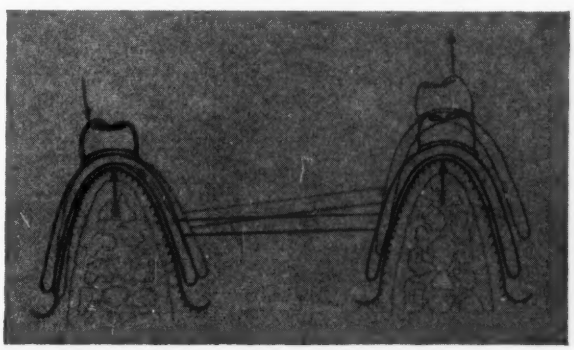

Fig. 4.—If the teeth are set buccal to the crest of the residual ridge the denture base will tend to rotate.

if the denture base can move tissueward without interference by the occlusal rest, the concept of a fulcrum line, which connects the rest seats in the abutment teeth, does not apply until definite resorption has taken place, and the denture no longer functions in the manner for which it was designed. As far as clasp action is concerned, it means that the clasp will move in the same direction as the adjoining denture base and not opposite to it, thereby eliminating the injurious lever action to the abutment teeth.

RECIPROCATION

The commonly used term "stabilizers" to describe the stabilizing function of rigid portions of clasps, and other rigid parts of the partial denture, leads one to believe that they are the main factors in stabilizing the appliance. In the final analysis, however, the teeth and the anatomic structures supporting the denture base are the actual stabilizers of the appliance. Stabilization of the partial denture is obtained through the placement of rigid parts of the appliance against the basal seat and the teeth. The quality of support which these structures offer will be the most important contributory factor to denture stability.

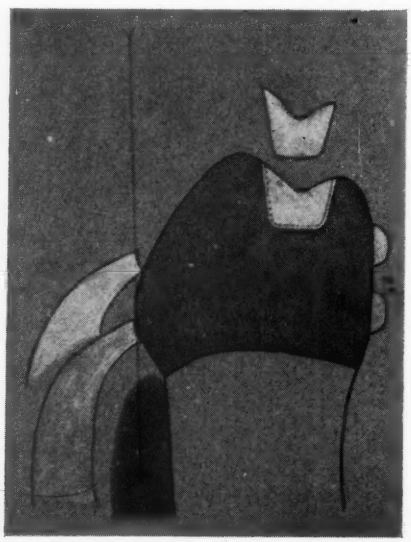

Fig. 5.—The buccal clasp arm as it flexes over the widest diameter of the abutment tooth. The rigid lingual clasp arm reciprocates this stress.

All stresses to the abutment tooth, except those in the direction of its long axis, should be considered as harmful and must be controlled by reciprocation. This holds particularly true for lateral stresses exerted by the flexible clasp arm as it passes over the height of contour of the abutment tooth during insertion and removal of the partial denture, and as it resists displacement during function (Fig. 5). Whenever any part of a clasp is positioned in an undercut, it will, during insertion and removal of the appliance, have to flex over the widest diameter of the tooth. The clasp arm will resist displacement with a force equal in amount

to that required to make it flex, and this force will be transmitted to the abutment tooth which will be pushed laterally, unless supported and held in position by an opposing part of the appliance. The amount of force exerted upon the tooth by the clasp arm will be greatest at the time when the terminal clasp end passes over the height of contour of the tooth. This force will decrease gradually, as the denture is seated, until the clasp reaches its final position on the tooth and the force becomes zero.

In the process of mastication, the clasp will be called upon constantly to resist displacement of the partial denture. It fulfills this requirement by resisting flexion and thereby it exerts an equal force on the abutment tooth, but in the reverse direction. These stresses, however, can be minimized by other parts of the appliance so designed and placed as to reciprocate the original force. Thus, the abutment teeth will be stabilized and be better equipped to stabilize the partial denture.

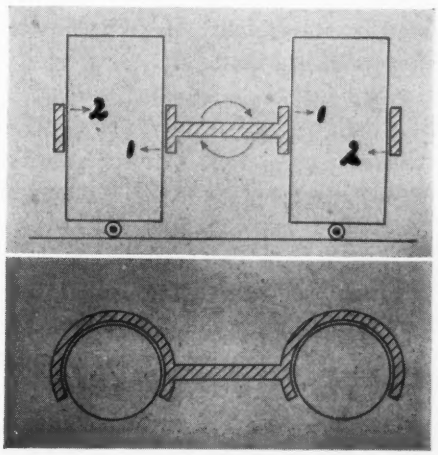

Fig. 6.—Hinged cylinders with a rigid appliance. A rotational force will cause the primary stresses at *1*, which will tend to push the cylinders apart. Reciprocating contact at *2* will prevent this action.

Reciprocation, therefore, can be described as the function of certain parts of the partial denture to neutralize stresses exerted upon the abutment teeth by other parts of the denture.

Smith[5] suggests that the lingual clasp arm be made rigid and placed against a lingual surface of the abutment tooth so modified as to be practically parallel to the path of insertion (Fig. 6). The buccal or labial clasp arm should be designed to engage an undercut for retention. This will assure reciprocation of the stresses exerted against the tooth by the buccal clasp arm during insertion and functioning of the appliance. The procedure is to modify the tooth contour by means of a full, veneer, or ¾ crown, thus allowing for the placement of a deep recessed occlusal rest and the shaping of lingual tooth surfaces nearly parallel to each other and to the path of insertion.

The use of two opposing flexible clasp arms is contraindicated, except when used in conjunction with deeply recessed rests. The uneven curvature of the buccal

and lingual tooth surfaces, as well as the uneven flexibility of the clasps, make it difficult to design clasps which will exert a like amount of stress at exactly the same time.

Roach[6] suggested the use of two bar-type clasp arms placed opposite to each other on the buccal and lingual surfaces of abutment teeth. Both functions of retention and stabilization are assigned to these clasp arms. Since stabilization is associated with rigidity, and retention with flexibility, it cannot be expected that any one element would be able to perform both of these contrary functions as well as it should.

STABILITY VERSUS RETENTION

Stability of the appliance is a most important requirement for its proper function and for the patient's comfort. Stability can be defined as the quality of the partial denture in resisting all stresses which tend to move it on or from its base. The need for retention has an inverse relationship to the amount of existing stability. Attempts to increase the stability of a basically unstable partial denture, by increasing the retention of clasps, invite trouble and the early loss of the abutment teeth. On the other hand, a stable appliance will have little need for tightly gripping clasps. Stability of the appliance in response to vertical stresses will be obtained by proper distribution of the load between the widest area of bone support and the abutment teeth.

Resistance of the appliance against stresses introduced by the traction of sticky foods (usually described as retention) can be obtained by the placement of a flexible clasp arm into an undercut area of a tooth so the clasp must flex before displacement is possible, or by multiple contacts of clasps and recessed rests against parallel surfaces of the abutment teeth, or by a combination of both methods.

The mechanism of resistance against displacement by means of rigid parts of clasps or rests, which are rigidly connected and which are in contact with parallel surfaces of abutment teeth, has been described as frictional retention. This type of retention is actually the result of reciprocation of lateral stresses, and is also the method used to provide retention in partial dentures using precision attachments as retainers.

If two cylinders are set parallel to each other (Fig. 6), and hinged at their base so as to permit tilting, and if an appliance is made to fit over and connect these cylinders by contacting their approximating and outside surfaces, the function of frictional retention can be explained graphically. If a rotating force is exerted upon the appliance, the surfaces of the appliance contacting the approximating walls of the cylinders will exert a lateral force which tends to force the cylinders farther apart. The surfaces of the appliance contacting the opposing walls of the cylinders, being rigidly connected with the other parts of the appliance, will reciprocate these lateral stresses and prevent any movement of the cylinders. Thus the original rotating force is controlled. The application of this principle to the design of abutment tooth restorations will require the use of deep recessed lug seats. The walls of these seats should be practically parallel to each other and to the lingual surfaces of the teeth. The need for additional retention by means of flexible clasp arms will be kept to a minimum. The major connector

must be rigid and the rigid portions of the clasps must be so placed as to contact more than 180 degrees of the circumference of the tooth. The abutment teeth will be stabilized by the partial denture, but a free vertical movement of the appliance will still be possible. It should be emphasized, however, that the use of this type of clasp design must be based upon a method of partial denture construction which will result in a vertical movement of the denture base during function.

SUMMARY

Masticatory stresses exerted on the base of a distal extension partial denture are transmitted to the supporting anatomic structures through contacting parts of the appliance. If the parts are incorrectly designed or constructed, they will alter the direction and force of these masticatory stresses, and may create stresses which are not within the physiologic limits of tissue tolerance. Movement of the denture base as a result of vertical stresses and the displaceability of the mucosa must be recognized and dealt with in tissue-borne appliances. The partial denture should be constructed so this movement is vertical in relation to the supporting bone. Clasps and rests should be designed to allow for this vertical movement of the denture base. Stresses other than those vertical to the abutment teeth should be reciprocated. Reciprocation is best obtained by contact of rigid parts of the partial denture with modified axial surfaces of abutment teeth which are made parallel to each other and to the path of insertion.

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ATTACHMENTS FOR PARTIAL DENTURES WITHOUT CLASPS

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A PRECISION ATTACHMENT can be used where a great amount of stress and occlusal force is present, or for splinting teeth in periodontal conditions, or in general restorative dentistry. It is necessary that those teeth which are to be used for retention must be covered with a cast crown or a two-piece crown.

A thimble is first cast, then a gold backing with an acrylic resin buccal or labial surface is made. The attachment used involves the mesial, distal, occlusal, and lingual surfaces. After the crowns have been seated in the mouth, minor occlusal adjustments are made, if necessary. An impression of them in place is made with Truplastic. A cast is then poured in stone, and low fusing metal is used for seating of the gold casting so that a perfect seat can be established without distortion of the cast when the castings are removed and replaced on the cast. The cast is then set and adjusted on a parallelometer so that the gold castings can be cut on a 15 degree angle. A tapered bur fissure can be used to make the cuts. The preparations in the casting are made similar to those for three-quarter crowns.

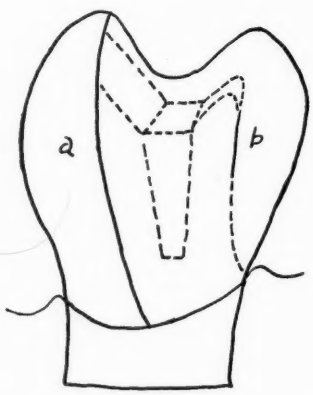

Fig. 1.—*a*, The veneer cast crown. *b*, The ¾ casting for the clasp.

The mesial and distal grooves are cut to a depth of at least one-half of the diameter of the bur. The lingual surface is cut away so there is space enough for the amount of bulk required for a three-quarter crown. The lingual gingival margin is cut as shown in Fig. 1.

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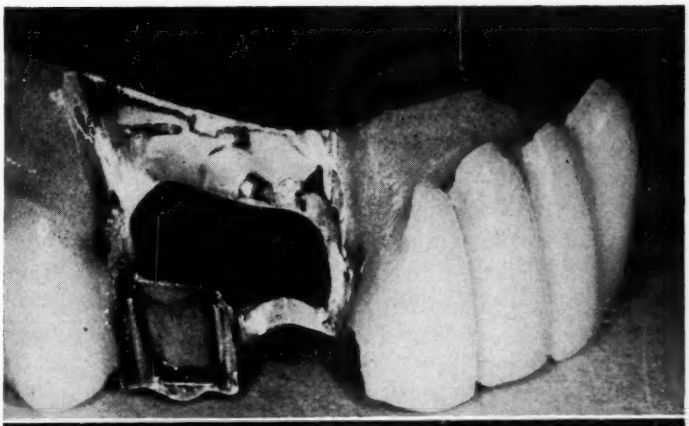

Fig. 2.

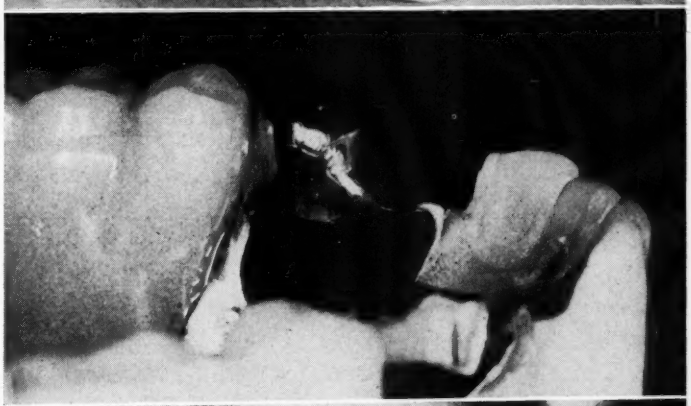

Fig. 3.

Fig. 4.

Fig. 2.—The buccal side of the attachment to the partial denture.
Fig. 3.—The lingual side of the attachment to the partial denture.
Fig. 4.—The partial denture in place.

The occlusal surface is cut away so a "V" shape groove connects the mesial and lingual grooves (Fig. 1). The attachment is then carved in wax, to conform to the anatomy of the teeth involved, and cast. The attachment must fit accurately, and must go to place and come off easily. The cast crowns and the attachments are set in place in the mouth, and the occlusion is corrected.

A lingual bar frame is designed in wax with truss arms on the mesial or distal surface of the cast three-quarter crowns. The cast three-quarter crowns are used as clasps (Figs. 2, 3, 4). The lingual bar frame is cast, seated in the mouth, and adjusted. A matrix is made with the three-quarter crowns and the lingual bar frame seated in place so that the correct relations are established. Then, the three-quarter crowns are soldered to the lingual bar frame.

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CENTRIC OCCLUSION AND THE FREE-WAY SPACE

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THERE HAS BEEN MUCH in our literature concerning the free-way space and its relationship to all branches of dentistry. The works of Niswonger,[1] Thompson,[2] and others would seem to be conclusive. However, there seems to be a vacuum existing between this knowledge of the stomatognathic system and its application to successful diagnosis and treatment planning. I will discuss this viewpoint as related to the dentition and crown and bridge prosthodontics.

We certainly accept the fact of physiologic rest position.[3] We also know that when the mandible is in physiologic rest position, a space described as the free-way space (interocclusal distance) exists between the mandibular and maxillary teeth. This free-way space, or interocclusal distance, is an all-important criterion upon which any restorative procedure that increases the length of the clinical crowns of a dentition must be based. This same principle applies to the construction of a splint, or to any type of construction within the interocclusal distance.

A practical procedure for determining the free-way space is to take two measurements: first, the distance between the nasion and gnathion (or two similar dots or lines placed on the face) while the mandible is in physiologic rest position; and second, the distance between these points when the teeth are in centric occlusion. Physiologic rest position is relatively easy to determine. It is a position of complete relaxation of all structures about the mandible. A patient can be told to relax the mandible as he does his arm in dropping the arm to his side. Physiologic rest position is assumed also after swallowing, and after the pronunciation of certain words and letters. This measurement should be checked a number of times, but normally it can be done in a matter of a few minutes. Centric occlusion is the initial point of contact of the mandibular with the maxillary teeth when the mandible closes on the hinge axis from physiologic rest position. The distance between the two reference points is measured when the teeth are in contact. The free-way space is the difference between the measurements at physiologic rest position and at centric occlusion. If, for example, the nasion-gnathion measurement in physiologic rest position is 50 mm., and in centric occlusion it is 47 mm., the free-way space is 3 mm. or a normal free-way space. This might be referred to as the approximate minimum free-way space allowance which must be maintained throughout all restorative procedures.

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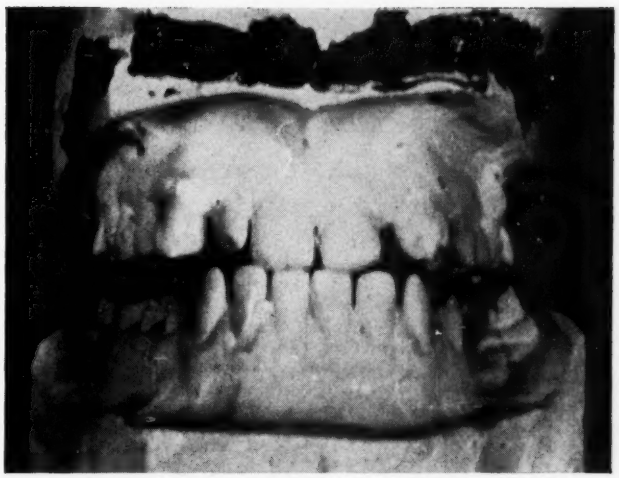
To place further emphasis on the accuracy of centric occlusion, we sometimes refer to this position as "true centric occlusion." This emphasizes the importance of any premature contact on closure from physiologic rest position that results in displacement of the mandible to obtain increased tooth contact. The mandible is still in centric position when this first contact of teeth is made, whether only one cusp of each of two opposing teeth is in occlusion, or whether all teeth make contact in a position of so-called normal occlusion. This first point of contact must not only be noted but it should also be registered, and the study casts should be mounted from this registration. This is the occlusion that occurs when the mandible is in centric relation, and is centric occlusion. The mounted study casts will then allow the operator to duplicate on the articulator the movements of the mandible required to obtain a maximum occlusion. If such a movement be necessary, it is strictly a functional relationship which results from displacement of the mandible. Such a case is described in Fig. 1,*A*. The functional occlusion (Fig. 1,*B*) in this case is a Class III relationship, and it points out the obvious error if diagnosis and treatment planning were based on the functional relationship. This also points to the frequent error in diagnosis resulting from articulating study casts instead of determining centric occlusion, and accurately mounting the casts in centric occlusion (Fig. 1,*C*). I have knowledge of more than one such case in which all the maxillary teeth were extracted and then, upon the recording of centric relation for complete denture construction, it was noted the ridge relationship was normal instead of the Class III relationship which had been expected. It is from such cases that we should be able to appreciate the importance of centric occlusion, and to differentiate from that of functional occlusion and its importance in treatment planning.

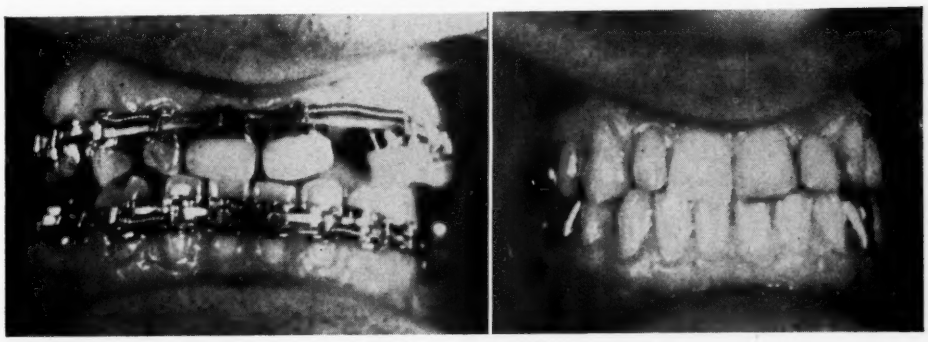
The case shown in Fig. 1,*A* was first treated by an orthodontist (Fig. 1,*D*). The main objective was to move the lower anterior segment distally to allow for a degree of vertical and horizontal overlap, thereby allowing further closure in centric relation. *The free-way space as measured from rest position to the first point of contact (centric occlusion) prior to orthodontic treatment was inadequate.* Orthodontic treatment increased this free-way space to 2.5 mm. At the same time, space was obtained for the replacement of the upper left lateral incisor, and other rotations were accomplished to improve the possible restorative result. The patient was 35 years of age at the beginning of orthodontic treatment, and was treated for a period of 10 months. The rehabilitation by crown and bridge prosthodontics brought the case to a successful conclusion shortly thereafter (Fig. 1,*E*). It is not the technical procedures accomplished in this case that are important here, but rather the diagnosis of centric occlusion and the relationship of centric occlusion to the free-way space. The treatment plan allowed for adequate free-way space after the restorative procedures were completed.

Fig. 2,*A* shows a case of a lesser degree but of no less importance in treatment planning. Fig. 2,*B* shows the result after a relatively simple equilibration prior to the construction of a partial denture. Physiologic occlusion has thus been restored. There are many more such cases, but the point is *not* to miss this important diagnostic approach. The correction of all such malfunctioning occlusions must be a part of treatment planning.

A. *B.*



C.



D. *E.*

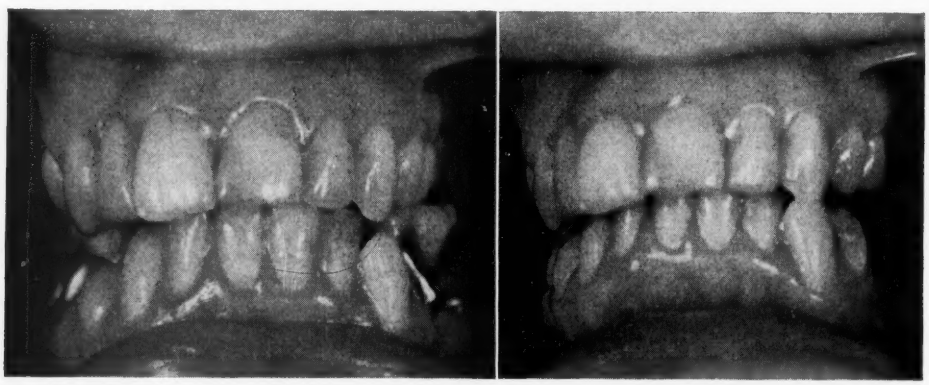
Fig. 1.—*A*, Premature contact in the anterior region upon closure on the hinge axis into centric occlusion. *B*, The same patient closed into a functional relationship. Note the anterior displacement of the mandible. *C*, The study casts mounted in centric occlusion. *D*, Orthodontic treatment. (Courtesy of W. H. Day, Colonel, Dental Corps, United States Army.) *E*, The completed case.

ERRORS IN DIAGNOSIS

We can learn from our errors. One of the errors that has come to our attention is illustrated in Fig. 3,*A*. This patient had sought dental care because of pain in the temporomandibular joint. The erroneous diagnosis had been made that "the bite was closed." As a result of the diagnosis, a splint which did not allow for normal free-way space was placed on the mandibular teeth. Within nine months, the posterior teeth had intruded into the bone (Fig. 3,*B*) so that, when the splint was removed, considerable space existed between the posterior maxillary and

A. *B.*

Fig. 2.—*A*, Premature contact on the upper right central incisor upon closure on hinge axis into centric occlusion. *B*, Correction is accomplished by simple equilibration.



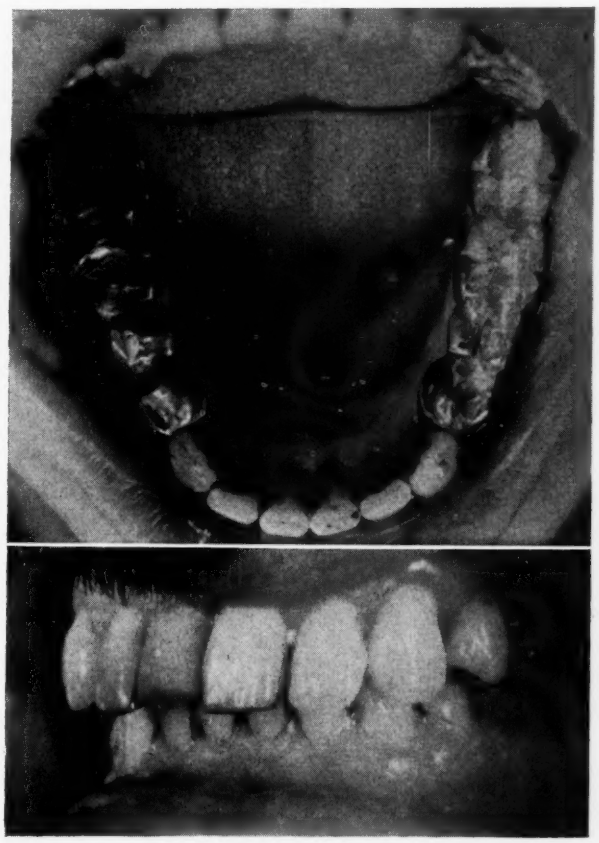
A. *B.*

Fig. 3.—*A*, A removable splint eliminating the interocclusal distance. *B*, The intrusion of the posterior teeth caused by the splint built within the interocclusal distance.

mandibular teeth when the anterior teeth were in occlusion. The temporomandibular joint pain had decreased for a few weeks after the insertion of the splint, but then it returned with increasing severity. The problems of treatment are now considerably more complex than before as a result of the error in diagnosis and treatment planning. This patient did not have a free-way space in excess of the normal, and any treatment which increases her vertical dimension in centric occlusion is and was contraindicated. The splint was contraindicated.

A similar case is shown in Fig. 4,*A*. The metabolic processes could not keep pace with the destructive forces,[4] and an acute periodontal condition existed within nine months after the insertion of splints. The splints were removed, and the upper left first and second molars were extracted. Fig. 4,*B* shows the space existing in the posterior region while the anterior teeth are in occlusion. In my opinion, these posterior teeth have been intruded by the forces resulting from interference with the normal free-way space. When the metabolic processes cannot keep pace with

A.



B.

Fig. 4.—*A*, Splints cemented to place within the interocclusal distance. *B*, The posterior teeth do not occlude as the result of the intrusion of the teeth due to the splint being within normal interocclusal distance.

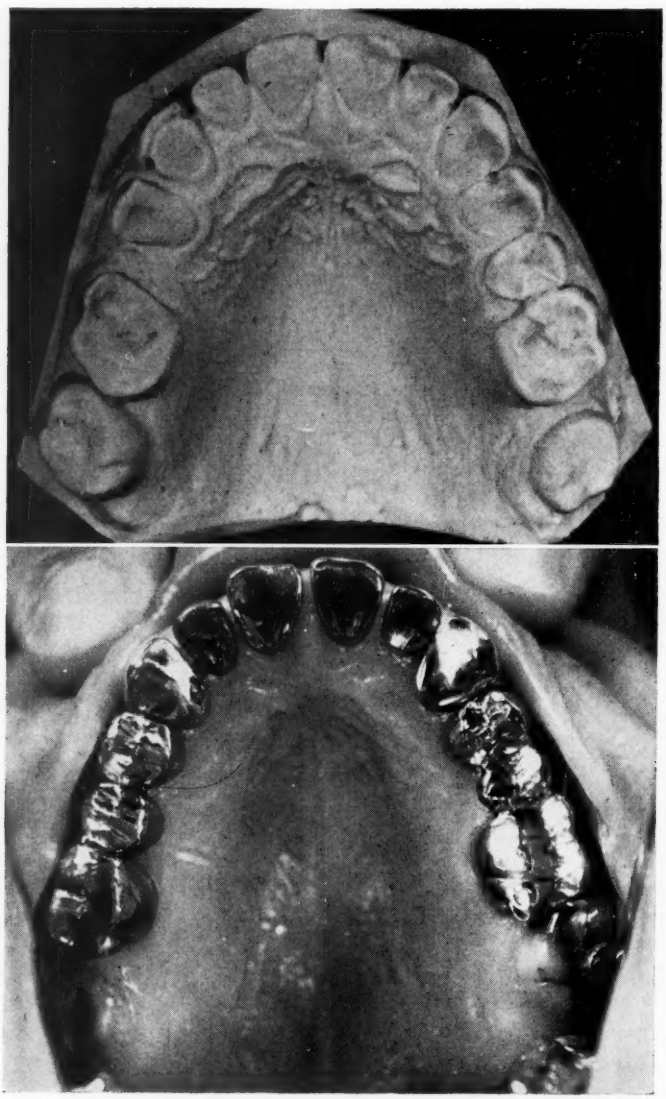
the destructive forces, there is a complete periodontal breakdown. The splints were used in this case to simplify the construction of a more esthetic anterior bridge. Restorations were to have been constructed for all posterior mandibular teeth to decrease the vertical overlap and increase the horizontal overlap. Again, this points to the limitations imposed by the free-way space, and the ultimate failure resulting from making restorations beyond the physiologic limits of the interocclusal distance. A statement is sometimes made to the effect that the restorative pro-

cedures should not open "the bite" beyond rest position. This would indicate a lack of appreciation of the necessity for a free-way space and the physiology of the masticating apparatus.

THE USE OF SPLINTS

The routine use of splints prior to restoring occlusion by means of crown and bridge prosthesis can well be questioned. With the knowledge we have concerning

A.



B.

Fig. 5.—*A*, An upper cast showing loss of coronal anatomy. A similar condition existed in the mandibular dentition. *B*, The completed upper restorations. Similar restorative procedures were accomplished on mandibular dentition.

the vertical dimension and the free-way space, we can arrive at a treatment plan which is scientifically correct, and need not resort to a "trial and error" method to "see if the patient can accommodate at a given vertical dimension." I can see no reason for such a procedure if we do not restore beyond physiologic limits; that is, if we allow for a *minimum* of 2 to 3 mm. of free-way space *after* completion of the treatment. A splint might be used to ascertain whether or not such treatment would relieve the temporomandibular joint pain. However, the initial treatment plan should be based on the opinion that the restorative procedures were desirable, in any event, to place the oral structures and their associated parts in the best possible condition for the longest possible period of time.

The failures resulting from an increase of the occlusal vertical dimension should certainly make one more cautious in prescribing such treatment. It has been my observation that the necessary allowance for free-way space does not exist in many cases, even when such an increase might be desirable for restorative convenience. Such cases are those with a deep vertical overlap with little or no horizontal overlap.

Cases involving severe abrasion might lead one to expect an increase in the free-way space. If this were true, free-way space measurements of 5, 6, and 7 mm. would be found frequently. However, this is not observed. It appears that the eruptive forces keep pace with the loss of the coronal anatomy (Fig. 5,*A*). In this case there is almost complete loss of occlusal anatomy of the posterior teeth. The correct plan of treatment restores more normal anatomy without increasing the vertical dimension of centric occlusion. After restoring the cusp height and inclined planes of the posterior teeth (Fig. 5,*B*), the tooth guidance in occlusion allows for the preparation and restoration of the anterior teeth.

SUMMARY

We can conclude from the evidence we have, that free-way space is a physiologic necessity. We cannot successfully insert splints, be they removable or fixed, or increase vertical dimension by crown and bridge prosthesis, unless the normal free-way space is maintained after the treatment. Therefore, many cases of mutilated occlusion must be rehabilitated without increasing the vertical dimension of centric occlusion. Establishing a more normal plane of occlusion and restoring a more normal occlusal anatomy will result in bringing the case to a successful conclusion.

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PROSTHETIC REHABILITATION OF A CLEFT PALATE PATIENT SUBSEQUENT TO MULTIPLE SURGICAL AND PROSTHETIC FAILURES

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THE LITERATURE IS REPLETE with numerous reports of the design and construction of speech appliances for the unoperated as well as for the unsuccessfully repaired cleft palate. For the most part, such reports are primarily concerned with the technology of the appliance, rather than its contribution to the physiology of speech. The wide variety of prosthetic designs described reveal few fundamental principles that may serve as a guide in the treatment of the complex and individual problem. This is particularly true where prosthetic rehabilitation is required for the patient who has been unsuccessfully treated by surgical procedures. In such instances, great ingenuity is required to overcome deficiencies in maxillary development and loss of dental units as well as to provide for velopharyngeal valving. Since the prosthodontist's success is proportionate to his understanding of the physiology and pathology of the oral and nasopharyngeal spaces, the need exists to describe the prosthetic design in terms of the individual pathology, and to relate the prosthetic contribution to the total program of rehabilitation.

The present report is concerned with the case of a young woman for whom surgical procedures, as well as a prosthesis, had failed to produce adequate cosmetic and functional improvement. A series of cephalometric and laminagraphic films have been employed to demonstrate the structural and functional deficit encountered, the reasons for previous therapeutic failure, and the means by which successful rehabilitation was achieved.

CASE REPORT

An 18-year-old white woman was referred to the National Institute of Dental Research by her family dentist. She presented a repaired bilateral cleft of the lip and palate and was wearing a speech appliance. The history of this patient, a foundling, is dramatically recounted in the words of her foster mother:

> When the patient was three days old, Dr. . . . . operated on her lip. She came to me when she was six months old, on August 13, 1936. I had her

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over a week before I knew what was the matter with her. She took down with whooping cough. When she was eighteen months old, the County Welfare Department brought her to the hospital where Dr. .... operated on her mouth, and injured a muscle. After that she had no more operations until she was three and a half years old. Then Dr. .... started to operate to close her mouth with a single operation by drawing two sides together. That didn't work so after that he did another one. When she was four years old he brought her to the hospital and he separated her upper lip from her gum. After that we were able to feed her a little with soft food. She discontinued the bottle, and started on her cup. After that I brought her to the hospital two years later and another operation was performed on the upper part of her mouth. When ten days passed, the doctor took the last stitches out, and her mouth was all open up again. She didn't return to the hospital again for three years. When he tried to do the same operation and the same thing happened again, it failed. And nothing was done to the patient until we took her to Dr. .... and he put braces on the upper part of her mouth for two years. At the end of two years, Dr. .... took a graft from her neck into her mouth and she was back and forth from 1949 until 1950, for different operations of skin graft. At the end of that time she was referred to Dr. .... for a set of teeth. After that she had trouble with her teeth and choked ever since.

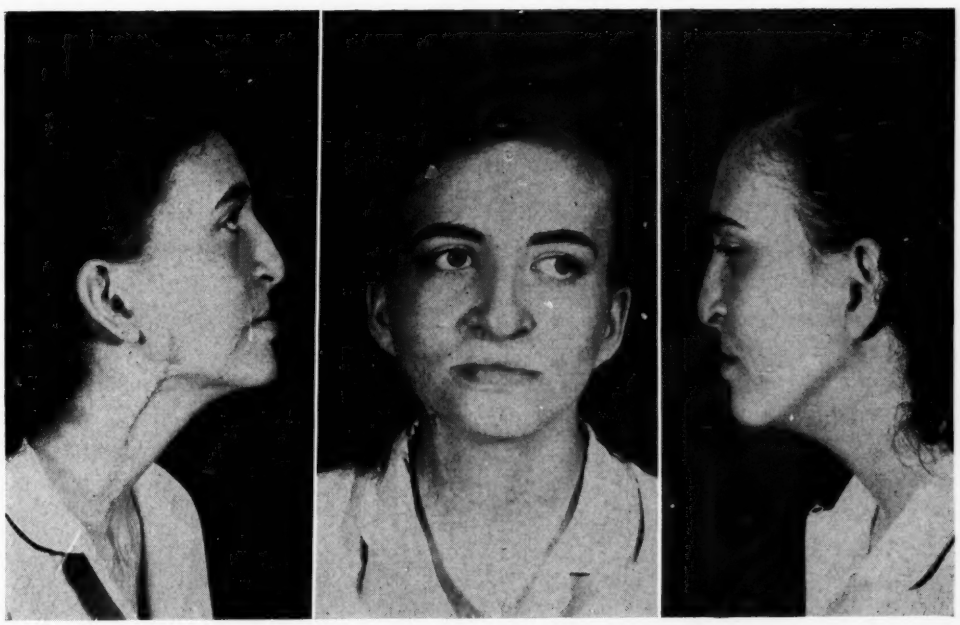

Fig. 1.—The patient without the prosthesis. Note the keloid scar at the donor site of the pedicle flap.

The latter surgical procedure involved the transplantation of a tubular graft from the right side of her neck (Fig. 1) into the oral cavity (Fig. 2,*B* and *C*) for the purpose of repairing the defect in her palate. The several stages involved in performing this surgery entailed a period of one year. It was following this procedure that she had been fitted with a speech appliance.

When first examined at the Clinical Center of the National Institute of Health, her speech was characterized by being extremely nasal and containing few accurate phoneme productions despite the wearing of the speech appliance There was little labial movement. Plosive production, as in the formation of the *p* and *b* sounds, was achieved by upper lip to lower incisor approximation rather than through bilabial approximation. Sounds such as *t* were produced by activating the residual air within the oral cavity rather than by conscious direction of the air stream. Her hearing was within normal limits.

Throughout, the patient was highly cooperative and, while not concerned about her speech, was willing to collaborate with the therapist in an effort to gain improvement. It was interesting to observe that her motivation increased greatly as treatment progressed and she discovered the rewards of more accurate speech. The examiners were impressed by the social and emotional adjustment of this young woman despite her history and physical handicaps.

From the history dictated by the foster mother and from the physical findings, it was clear that the various surgical and dental procedures did not fulfill the structural and functional requirements for good facial appearance, adequate occlusion, and intelligible and pleasant speech. In part, some of the structural deficiency could be attributed to the surgical removal of the premaxillary segment. The loss of this portion of the facial skeleton accounted for the lack of support for the upper lip (Fig. 1), and explained the absence of the maxillary incisors and alveolar process in the anterior segment of the maxillary arch (Fig. 2,*A*). The removal of the premaxilla served to extend the width of the opening between the oral cavity and the anterior portion of the nasal cavity on the right side (Fig. 2,*B*). Obviously, any plan for improved cosmetic appearance, better masticatory function, and articulate speech would necessarily involve prosthetic substitution for the missing premaxillary element.

The constricted maxillary arch not only produced a severe "cross-bite" relation with the lower dental arch (Fig. 2), but also prohibited proper tongue postures within the oral cavity. The profound architectural disturbances in the palatal vault, produced by the V-shaped dental arch, prevented the attainment of the lingual-palatal-dental configurations essential to the formation of many articulate speech sounds. As an example, the proper formation of the *sh* sound as in *shoe* would be virtually impossible in this instance.

The merits of transplanting a skin graft from the neck to the hard palate, as performed for this patient, are questionable on two counts. First, the operation introduced an unsightly keloid scar in addition to those the patient already possessed. Second, the transplanted tissue served no real functional purpose. At best, this tissue may be said to obturate the nasal cavity from the oral cavity through the extent of the greater portion of the defect within the hard palate. Functionally, this transplanted tissue was a pendant mass that greatly diminished the height of the palatal vault and hindered the range of tongue movements required in articulate speech. But the greatest shortcoming of this surgery was that it contributed nothing toward establishing a velopharyngeal mechanism capable of reducing the hypernasal quality of her speech.

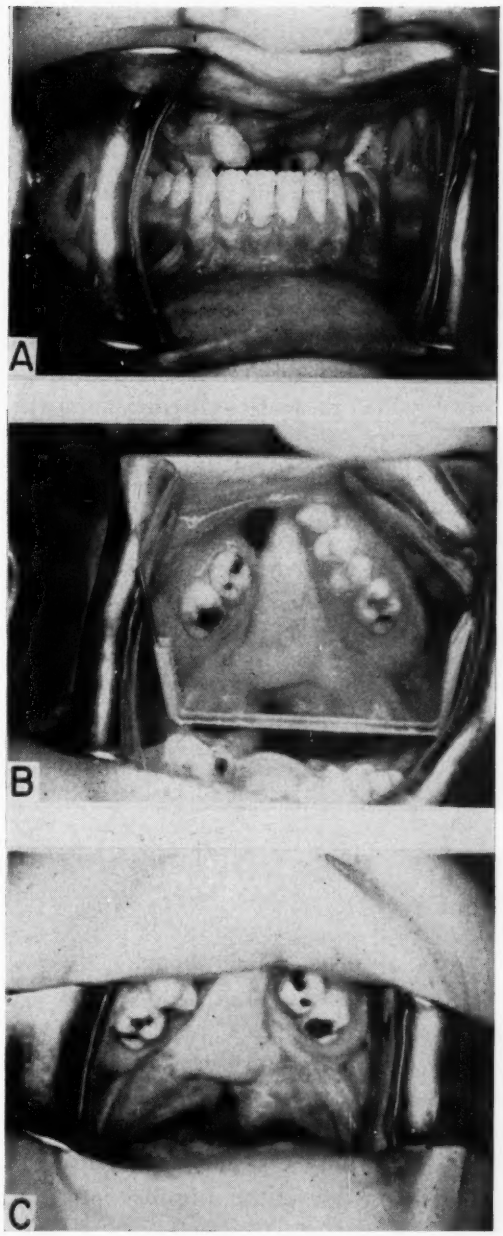

Fig. 2.—*A*, The teeth in occlusion. *B*, The skin graft employed to repair a portion of the cleft in the hard palate. *C*, The short soft palate.

In retrospect, the little good that the graft achieved, in terms of obturation, might have been more readily accomplished by prosthetic means and without diminishing the height of the vault or introducing new scar tissue. With the transplanted tissue in place, the design of a speech appliance was unnecessarily complicated. Although this impediment could now be removed, the undoing of all that had transpired for this patient would have been emotionally traumatic and might have destroyed her faith in the judgment of others.

OBJECTIVES OF TREATMENT

The several problems just described together with the desired end results could be categorized as follows:

1. The speech problem. Two separate, though interrelated, deficits were identified as barring the attainment of intelligible and pleasant speech. First, there was the quality of hypernasality arising from the inadequate mechanism for producing a separation between the oral and nasal portions of the pharynx. To substitute for this deficiency, a more effective pharyngeal section would have to be constructed for the speech appliance. Second, the articulatory faults in her speech seemed related to the faulty occlusion, the missing dental units, the abnormal palatal vault, and the inharmonious relationship between the upper and lower lips.

2. The plan for cosmetic improvement would entail prosthetic support for the upper lip. Concomitantly, a reduction in the excessive free-way space would tend to reduce the amount of overclosure and the accompanying forward thrust of the chin (Fig. 3).

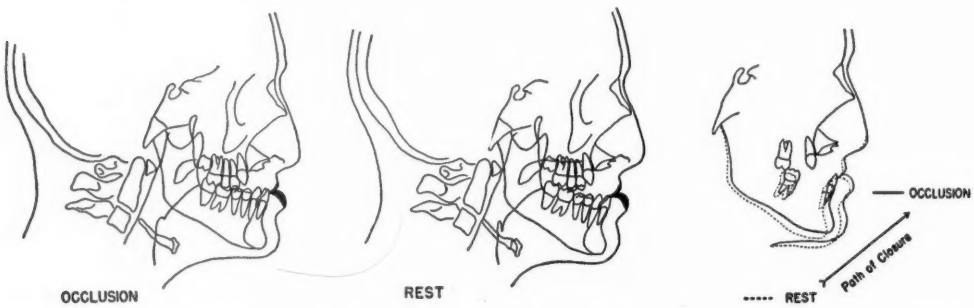

Fig. 3.—Tracings of lateral cephalometric films prior to rehabilitation and without the original prosthesis.

It was anticipated that the establishment of good occlusal relations, a more normal contour of the palatal vault, and an increase in dental height, would not only provide for the desired cosmetic and masticatory improvement, but would also assist in meeting the needs of articulate speech. It was decided that further consideration of additional plastic surgery for the purpose of revising the lip and nose be postponed pending a re-evaluation of this patient's needs once the prosthetic rehabilitation had been completed. The problem of correcting the keloid scar was primarily a surgical problem, not immediately related to the dental problem under discussion, and, therefore, not within the scope of this report.

LIMITATIONS OF THE ORIGINAL SPEECH APPLIANCE

To appreciate the design of the new speech appliance, it is essential that the reasons for the failure of the original appliance be understood. Clinical examination disclosed that the pharyngeal section of the appliance was deficient in its lateral and posterior dimension both at rest (Fig. 4,*A*) and during contraction of the velopharyngeal muscles as elicited during the sustained phonation of the vowel *a* or in the gag reflex.

Lateral cephalometric films, obtained during the sustained phonation of the vowel *u,* revealed that the soft palate was extremely short and incapable of contacting the posterior wall of the pharynx as is necessary in order to obtain valving of the nasopharyngeal port (Fig. 5,*A*). The occasionally observed anterior bulging of the posteror pharyngeal wall characteristic of the formation of Passavant's bar was not recorded in this instance. Clinical examination, however, disclosed considerable medial movement of the lateral walls of the pharynx at the level of the first and second cervical vertebrae.

With the original speech appliance in position, the cephalometric film, obtained during the sustained phonation of the vowel *u,* confirmed the inadequate extension of the appliance toward the posterior wall of the pharynx (Fig. 5,*B*). Vertically, the pharyngeal section was placed too low and within the oropharynx, instead of at a higher level in the nasopharynx where valving normally occurs. This low posture of the pharyngeal section also intruded upon the dorsum of the tongue, restricting the range of its movements and impeding the flow of the air stream into the oral cavity.

THERAPEUTIC TEST

To test our diagnosis of the defects of the pharyngeal section of the original appliance, we elected to revise this portion of the prosthesis in an effort to eliminate the component of hypernasality from her speech. This procedure was carried out by adding impression compound to the original pharyngeal section and completing the molding of the pharyngeal portion by the use of wax impression material. Our objective was to extend the prosthesis vertically and laterally.

From the imprint thus obtained, an acrylic resin addition was processed upon the old appliance. When processed, it was found that the inferior extension could be reduced without sacrificing the support of the pharyngeal section. Clinical examination disclosed that this new addition was situated at a higher level within the nasopharynx and was in closer approximation to the lateral pharyngeal walls (Fig. 4,*B* and *C*). The cephalometric films indicated that the reconstructed pharyngeal section of the original appliance contacted the posterior wall of the nasopharynx at the level of maximal movement of the pharyngeal muscles.

The lateral margins of the pharyngeal section were not in contact with the lateral pharyngeal wall at rest. However, during the sustained phonation of the vowel sound *ah* or during the gag reflex, the medial bulging of the lateral pharyngeal wall, resulting from the contractions of the salpingopharyngeus muscle, made contact with the margins of the pharyngeal section of the prosthesis and served to valve off the nasopharynx from the oropharynx (Fig. 6).

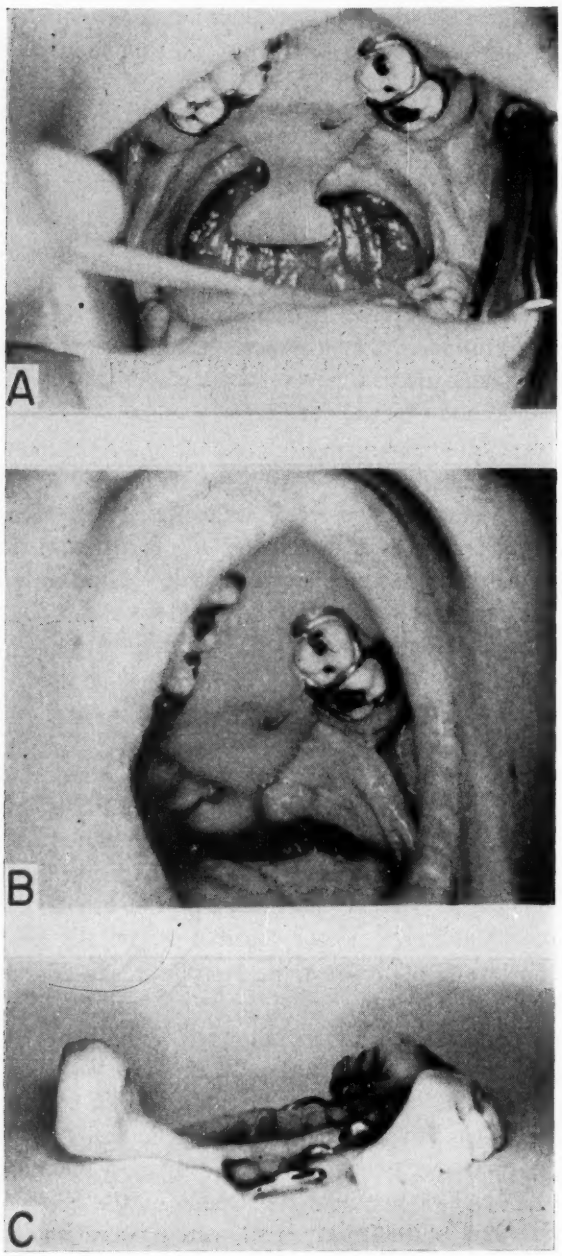

Fig. 4.—*A*, The original appliance. *B*, The modified pharyngeal section on the original appliance. *C*, A profile view of the modified pharyngeal section.

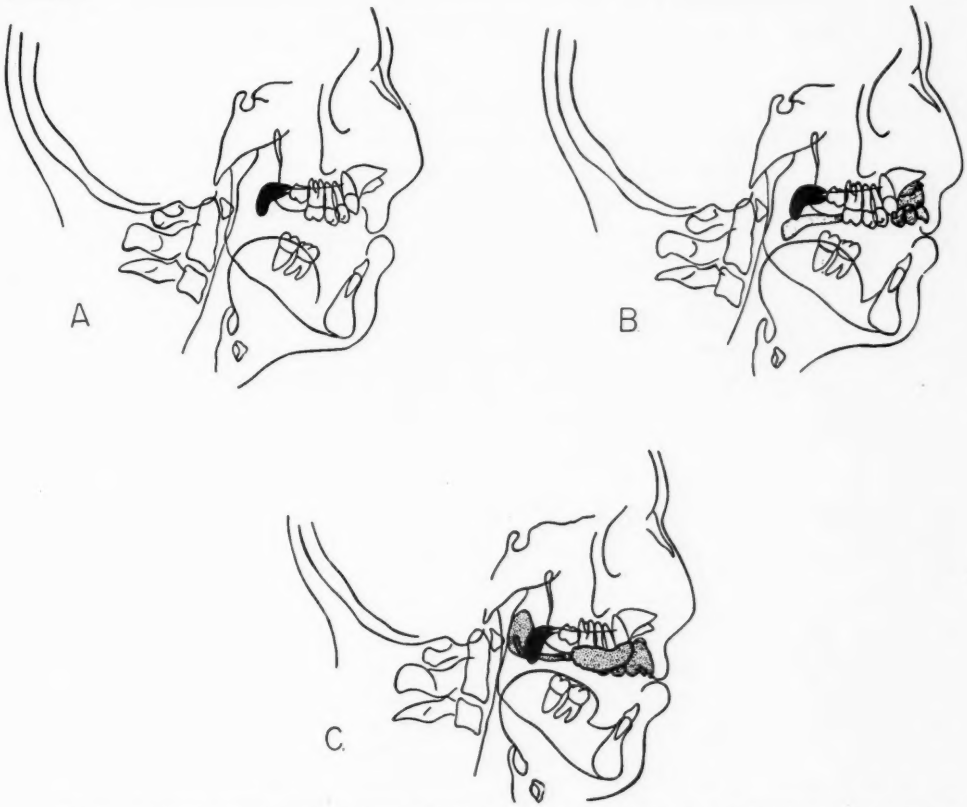

Fig. 5.—Lateral cephalometric films obtained during the sustained phonation of the vowel "u." *A*, Without a speech appliance. *B*, With the original speech appliance. *C*, With the new speech appliance.

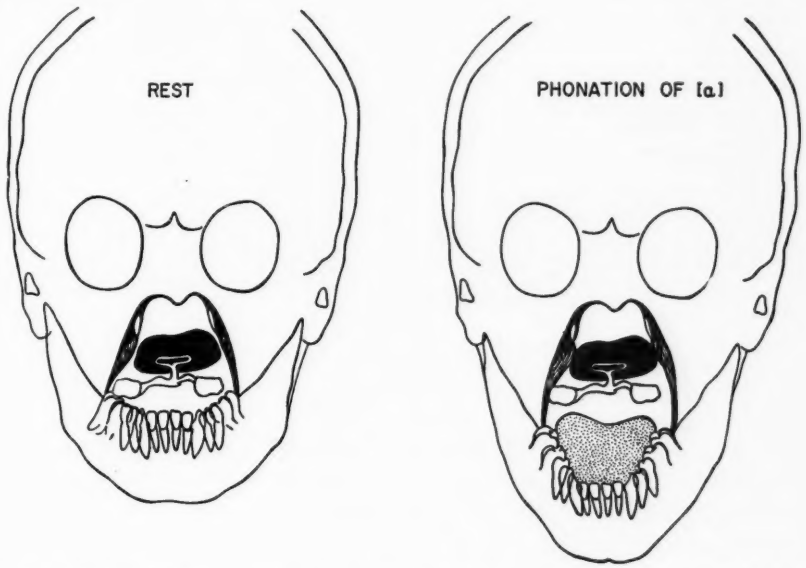

Fig. 6.—Schematic diagrams, based on frontal laminagraphic views at the level of the pharynx, to demonstrate the movements of the lateral pharyngeal wall in relation to the pharyngeal section of the prosthesis.

The results of this therapeutic test were encouraging for it served to reduce the hypernasality and, following minor adjustments, the patient did not complain of any discomfort in adjusting to the enlarged pharyngeal section. Indeed, she reported less leakage of food into her nasal passages. Encouraged by this success and by the patient's increasing desire to go on with treatment, our objectives for a much improved prosthesis were defined.

THE DESIGN OF THE NEW SPEECH APPLIANCE

The primary objectives of the new appliance were (1) to provide an adequate pharyngeal section for good nasopharyngeal valving, (2) to provide good occlusal relationships and a more normal contour to the palate, (3) to reduce the vertical free-way space and to increase the vertical dimension of the face, and (4) to provide for a more harmonious relationship between the upper and lower lip.

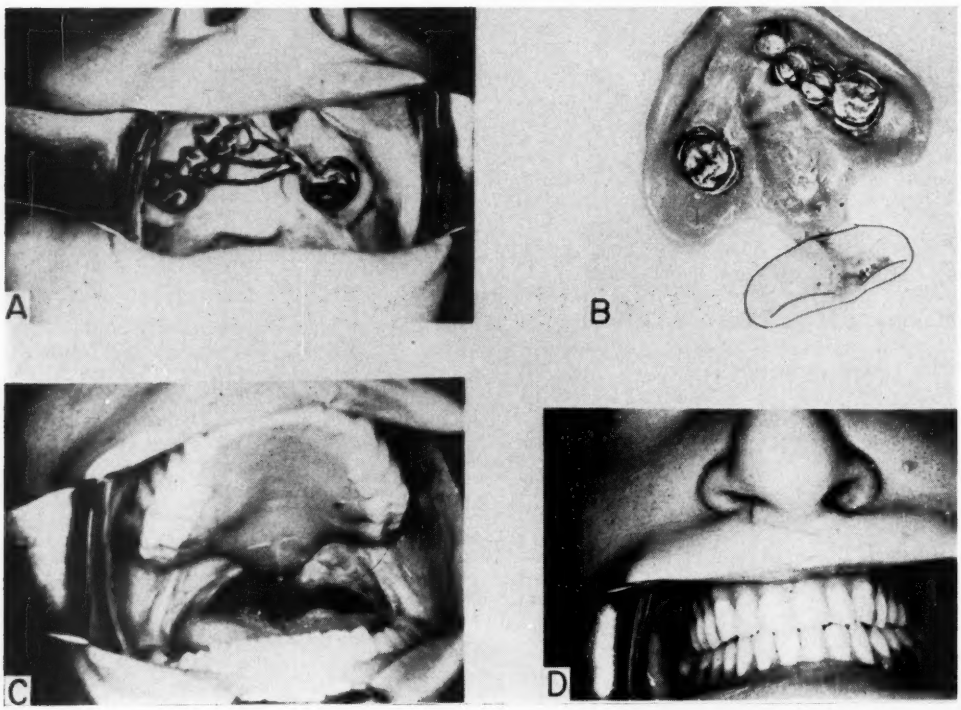

Fig. 7.—The new speech appliance. *A*, The gold palatal framework seated over gold crowns. *B*, The tissue side of the finished appliance. Note the width of the pharyngeal section. *C*, The finished appliance in place. *D*, The appliance in occlusion.

It became apparent that in order to fulfill the second and third objectives, the palatal section of the appliance would involve an overlay denture encompassing the remaining maxillary teeth. In order to protect these teeth from decay and to minimize the stresses imposed upon their supporting structures, it was decided that reconstruction of the clinical crowns of these teeth would be necessary. Each of the remaining teeth was crowned and the crowns were soldered together to add

rigidity and stability to the foundation for the new speech prosthesis. A gold casting was fabricated to serve as the skeleton for the palatal section of the appliance and to carry the clasps designed to retain the appliance. The artificial teeth were arranged in accordance with predetermined measurements for the reduction of the free-way space (Fig. 7). The manner in which the free-way space was determined is described in the section dealing with the evaluation of the new appliance.

When the palatal section of the appliance was completed and found to meet the specifications for improved labial relations, for increased vertical dimensions of the lower face, and decreased free-way space, it was decided to proceed with the construction of the pharyngeal section. A dovetail was cut into the under surface of the acrylic resin at the distal border of the palatal section of the appliance. A round gold wire loop (.040 diameter) was formed to extend from this dovetail into the nasopharynx, and to do so without impinging upon the remnants of the soft palate. This gold wire framework was to serve as the velar section, connecting the palatal portion to the pharyngeal portion of the appliance, as well as the skeleton for the pharyngeal section. Once the proper length and configuration of the gold wire was obtained it was fixed to the dovetail by means of wax and then rechecked in the mouth. Finally, the gold wire loop was embedded within the dovetail by means of acrylic resin.

Compound impression material was added to the gold wire frame in order to conform to the general outline of the nasopharyngeal port at the level of greatest muscular activity, and where the opening into the nasopharynx was narrowest in cross-section. When this approximation was obtained, smaller amounts of compound impression material and finally wax were added. An effort was made to muscle mold the pharyngeal section by having the patient phonate and swallow as well as rotate and flex the head upon the chest while the impression material was in a plastic state.

It should be noted that cephalometric films are extremely valuable adjuncts in obtaining an estimate of the relative position of the pharyngeal section within the nasopharynx. Attempting to make such estimates by clinical examination is fraught with errors. In order to examine the nasopharynx, the patient's head is generally extended in order to open the mouth widely. In so doing, the anatomic relations that exist in normal posture become greatly distorted. The differences in relation of the pharyngeal section of the prosthesis to contiguous anatomic structures within the nasopharynx, in varying postures of the head, is revealed in a series of tracings from lateral cephalometric films (Fig. 8).

With the patient's head in the Frankfort horizontal plane, the posterior aspect of the pharyngeal portion of the prosthesis appeared in slight contact with the pharyngeal wall and at a level opposite to the anterior arch of the atlas. Fixation of the head in extension, to the degree employed in examining with the mouth wide open, placed the anterior arch of the atlas at a level inferior to that of the pharyngeal extension of the prosthesis. In addition, the greater portion of the appliance no longer came into contact with the posterior wall of the pharynx. When the head was flexed upon the chest, the anterior arch of the atlas came in closer contact with the prosthesis suggesting that the appliance tended to compress the soft tissue of the posterior pharyngeal wall. The latter illustration clearly

demonstrated the need for fitting the prosthesis to this head position (Fig. 8). Inadequate correction for this posture of the head may cause the pharyngeal section to impinge upon the posterior wall of the pharynx producing discomfort and even ulceration.

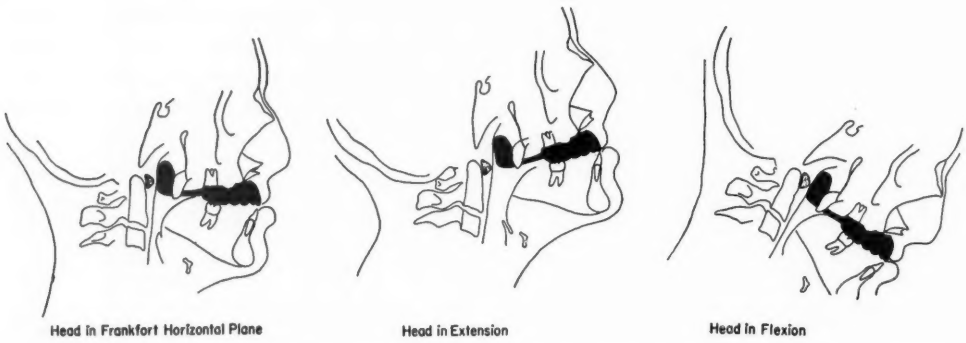

Fig. 8.—Lateral cephalometric films obtained with the head in varying positions to demonstrate the variable relation of the pharyngeal section to the contiguous anatomic structures.

CEPHALOMETRIC EVALUATION OF THE NEW PROSTHESIS

The means by which our objectives were achieved through the new appliance can be analyzed from the tracings of the cephalometric roentgenograms.

1. *The Change in Vertical Dimension.*—The lateral film obtained with the original appliance removed and the jaw closed in centric occlusion revealed considerable deficiency in vertical dimension of the dental area and a concomitant protrusion of the lower lip ahead of the upper lip (Fig. 3). The cephalometric headplate taken with the patient in rest position revealed a free-way space of approximately 6 mm. Clinical examination at various intervals indicated that this was probably a conservative estimate. Frequently, an interocclusal space of 13 mm. was registered in the anterior region. Superimposing the tracing of the film obtained at rest upon that in occlusion revealed that the path of closure was in an upward and forward direction (Fig. 3). There was a definite tendency to overclose resulting in an anterior displacement of the chin point. This served to accentuate the protrusion of the lower lip in its relationship to the upper lip.

With the new speech appliance in place, it was apparent that the vertical dimension of the denture area had been considerably increased. At the same time, the excessive protrusion of the lower lip in relation to the upper lip had been diminished. Despite the great reduction in the free-way space produced by increasing the occlusal vertical dimension, the patient experienced no discomfort and was able to maintain an interocclusal space of 2 to 3 mm. at rest (Fig. 9).

A comparison of two lateral cephalometric films, both taken with the teeth in centric occlusion, but one prior to rehabilitation and the other with the new appliance in place, served to document the changes in the patient's profile (Fig. 10). Increasing the occlusal vertical dimension resulted in a rotary movement of the mandible, with the center of rotation in the condyle, carrying the chin point in a downward and backward direction. This accounted for the improvement in

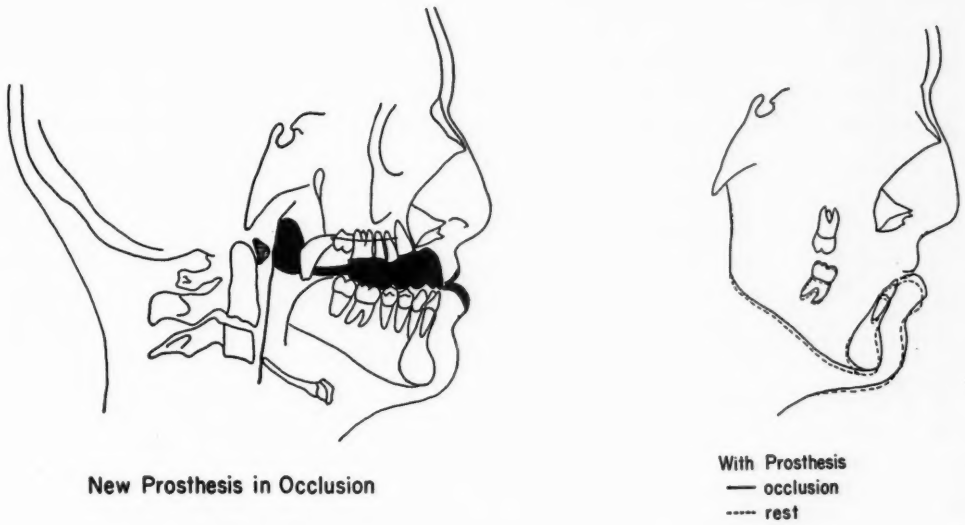

Fig. 9.—Cephalometric tracings with the new appliance in place.

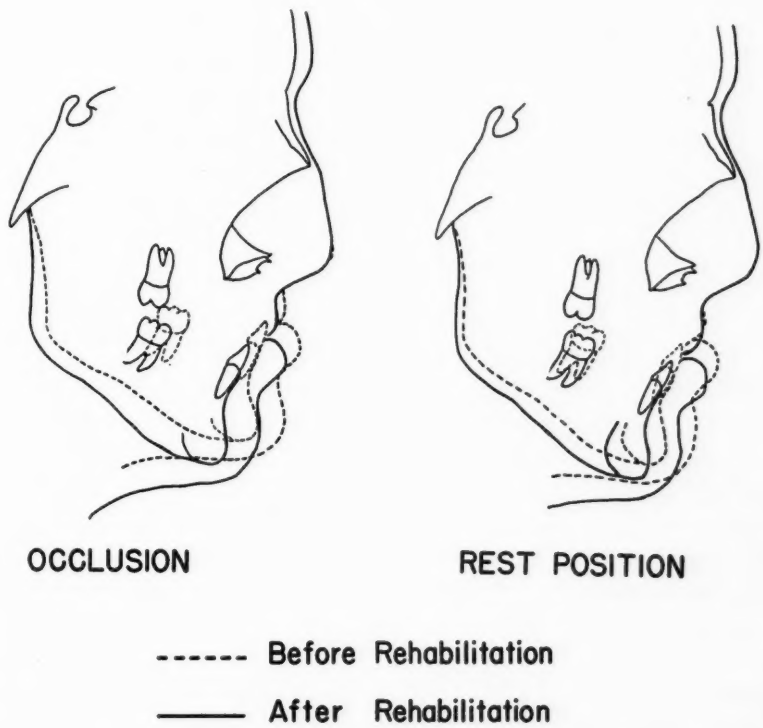

Fig. 10.—A comparison of the changes induced in the facial profile by the new appliance.

labial relations. In effect, the appliance did not "plump out" the upper lip, since the contour of the upper lip was actually distal to its original postion. The improvement in the relationship of the upper lip to the lower lip came as a result of increased vertical dimension and reduction of overclosure. Similarly, the films obtained in the rest position showed an improvement of comparable magnitude.

To confirm the observation that the process of increasing the occlusal vertical dimension did not involve an actual displacement of the condyle within the mandibular fossa, laminagraphic views of the right and left temporomandibular joints were obtained with the prosthesis in place, and without the prosthesis, while the teeth were maintained in occlusion. The laminagraphs confirmed the impressions gained from the cephalometric film, namely that the center of rotation was in the condyle and that the condyle-fossa relationships were not disturbed (Fig. 11). The increase in occlusal vertical dimension merely resulted in a rotation around the condyle with no displacement of the condyle within the fossa.

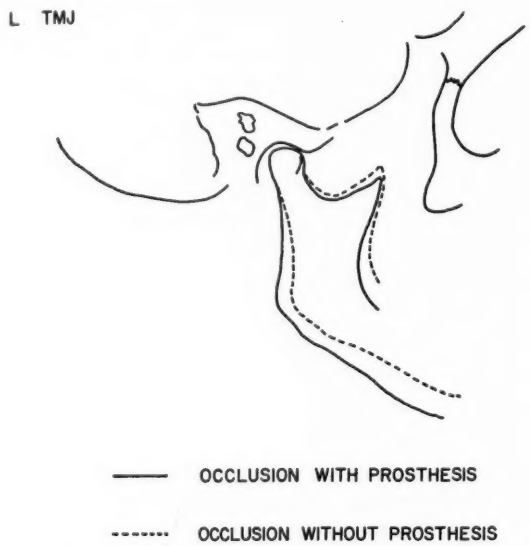

Fig. 11.—Tracings of laminagraphic films of the left temporomandibular articulation. Similar findings were recorded on the right side.

2. *Redesign of the Pharyngeal Section of the Speech Appliance.*—The lateral cephalometric films allowed for an accurate comparison between the old and the new speech appliances (Fig. 12). Compared to that of the original appliance (Fig. 4,*A*), the new pharyngeal section was totally different in size, shape, and location within the pharynx (Figs. 5,*B, C,* and 7,*B*). Despite the increased mass and the higher location of the new pharyngeal extension, it was apparent that the soft palate was not inhibited in its range of motion. The new appliance provided a definite impediment to the escape of the air stream into the nasopharynx during phonation and, by its higher position, offered freer flow of air through the oral cavity.

Further comparison of the original prosthesis with the new appliance revealed that, in rest position, the dorsum of the tongue assumed a higher position with

the new prosthesis (Fig. 12). This is probably due to the fact that the original appliance impinged upon the dorsum of the tongue preventing its higher posture in the oral cavity. Similarly, during the sustained phonation of the vowel *u*, the dorsum of the tongue was capable of a greater range of motion with the new appliance than with the old. Again, this is probably due to the greater freedom of lingual movement permitted by the new appliance.

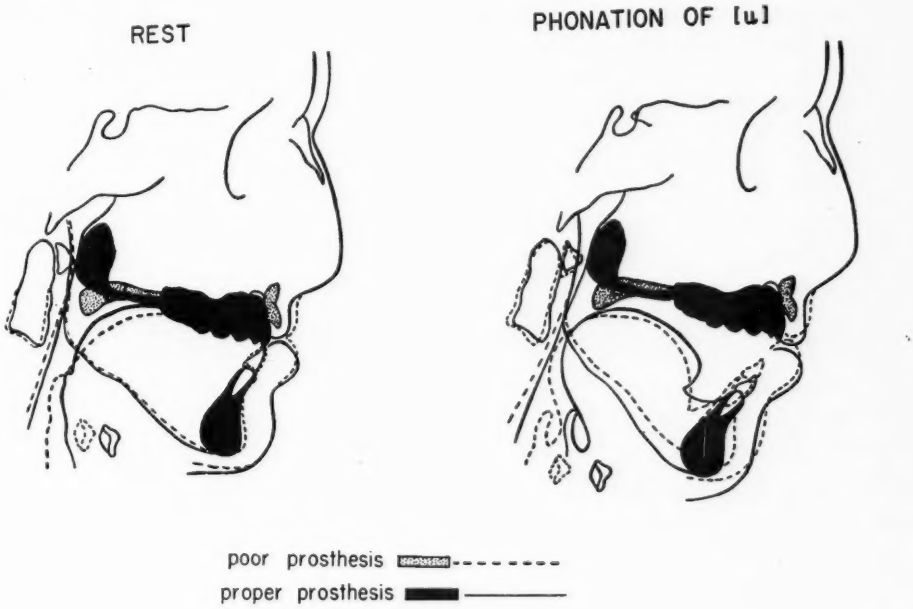

Fig. 12.—A comparison of the original and the new speech appliances. See text for explanation.

DISCUSSION

The cephalometric and laminagraphic studies described herein have provided an important adjunct to the design and functional evaluation of speech appliances. Such analytic methods provide a useful means for further study of a complex problem. We regard this case as a pilot study in an attempt to evaluate the mechanisms by which effective habilitation and rehabilitation can be achieved for patients with similar problems. In keeping with these objectives, it is interesting to summarize the mechanisms by which success was achieved for this patient.

The improvement in facial profile was not due to a "plumping-out" of the upper lip by the prosthesis, as is commonly thought, but rather by an increase in the vertical dimension of the denture region. Such increase served to reposition the chin point in a downward and backward direction carrying the lower lip into more favorable alignment with the upper lip. The repositioning of the mandible, as recorded in this instance, produced no profound morphologic or physiologic alterations in the temporomandibular articulation. It was achieved largely by a rotary movement with the axis of rotation in the condyle.

The architecture of the oral cavity was modified in several ways. By providing optimal occlusal relations, not only was masticatory efficiency improved but more suitable relations for articulate speech were established. This was confirmed by the observation that, with training, the patient is beginning to produce the following sounds in an acceptable manner: *t, p, b, k, f,* and *s.* Consonant sounds have been greatly improved, especially in continuous speech. Concomitantly, there has been a considerable reduction in nasality. This served to minimize the unpleasant nasal quality to her voice, which was originally noted. In view of the improved architectural situation and the increased motivation on the part of the patient, it is anticipated that the prognosis for continued improvement in terms of speech is excellent at the present time.

SUMMARY

Cephalometric roentgenography and laminagraphy are not only valuable research tools, but they provide essential diagnostic aids in planning therapeutic procedures, as well as documenting the results of therapy. The utilization of these tools to reveal the basic mechanisms by which effective rehabilitation can be achieved is demonstrated in the case of an 18-year-old woman for whom multiple surgical and prosthetic procedures had failed to produce an adequate result. The reasons for previous therapeutic failure, the rationale for our therapeutic design, and an evaluation of the final result were documented by a series of cephalometric roentgenograms.

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THE MARGINAL FIT OF THE FULL CAST SHOULDERLESS CROWN

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THE USE OF THE CAST gold veneer crown in dentistry has increased considerably in recent years. This is due in part to the growing acceptance, by both the dental profession and the public, of mouth rehabilitation and the practice of multiple splinting of teeth. It is also due to greater appreciation of the value of the veneer crown itself as discussed by the writer in a previous article.[1] Advancements in technique and better understanding of biologic principles have resulted in crowns that are compatible to both hard and soft tissues, that are more esthetic, and are easier to produce. The marginal fit of crowns is a fundamental factor in their success and is the subject to be discussed in this article.

The basic principles of crown construction are the same as they were years ago. An adequate preparation on a healthy tooth, with sufficient occlusal reduction to permit thickness of metal to withstand wear, sufficient axial surface reduction to permit extension of the crown beneath the gingival margin, freedom from undercuts, and a definite margin for crown adaptation, is an essential basis for the building of a satisfactory crown (Fig. 1). Observation of crown and bridgework in patients' mouths, and work seen on the benches of laboratories, show a wide gulf between these biomechanical principles taught the dental student and the results actually obtained in practice. The average patient presents himself with some degree of irritation to the gingival tissue around crowns. This may be due to reasons such as the overextended crown, the underextended or short crown, poor adaptation, the poorly contoured crown, or combinations of these, i.e., faulty marginal fit.

FAULTY CROWNS

The overextended crown usually encroaches beyond the cut of the preparation on the tooth, and the excess beyond the margin of the preparation is usually not in contact with the tooth surface. This overhang impinges in the gingival tissue, irritates and often causes edema and proliferation of the gingival tissue, destruction of the marginal alveolar bone, and ultimate loss of the tooth. The overextension of the crown is usually due to inaccurate technique and/or a desire of the dentist to "play safe" by making it long enough to cover the preparation or to extend beneath the gingival margin.

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The short crown fails to cover the cut surface of the prepared tooth and often does not extend below the gingival margin. This uncovered ground tooth surface is often sensitive to sweets and to temperature changes, and it invites the development of caries and causes gingival irritation. Also, it is usually due to inadequate technique and a willingness of the dentist to accept impressions that are incomplete.

The poorly adapted crown is one in which the crown is not in close adaptation to the preparation at the gingival margin—in distinction to being too long or too short. It, also, is due to faulty technique and is usually caused by a distortion of the impression at the time of its withdrawal. The result is a leaking crown with an irritating margin, subsequent caries, and other drawbacks.

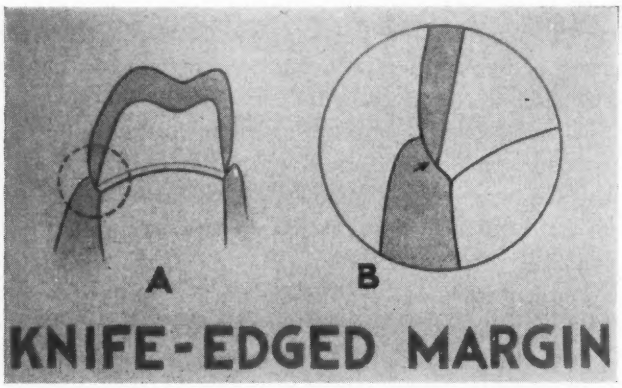

Fig. 1.—*A*, Cross-section of a crown on a preparation. *B*, Enlargement of the marginal area showing the ideal relationship of the preparation, crown margins, and the gingivae.

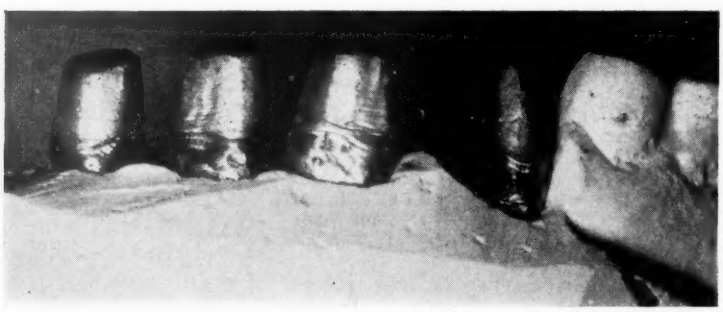

Fig. 2.—Dies showing definite margins.

The poorly contoured crown is one in which the margin may or may not fit the finishing line of the preparation. It may have an excess contour which impinges on the gingival tissue and deflects food over and away from this tissue, thereby depriving it of its normal stimulation; or it may be undercontoured, and permit the impaction of food into the gingival crevice, thereby stripping the gingival tissue away from the tooth. Either will cause irritation of the surrounding tissue, and may lead to the loss of the tooth.

The crowns seen in the average commercial laboratory show a reasonably good adaptation to the die, but an examination of the die makes one wonder what the result will be in the mouth. It is rare to see a die with a clear, distinct margin, showing completely around the 360° of its gingival circumference (Fig. 2). Definite shoulders, angularity, irregular rise and fall of the gingival margin, gross overextension of crown margins beyond preparation margins, and drag marks indicating surface distortion by calculus or undercuts of the impression are a few of the readily discernible faults. These observations point up the need of greater understanding and care in full crown construction.

TECHNIQUES OF CONSTRUCTION

A number of methods for crown construction are used, and all produce adequate results when they are expertly executed. The banded crown, in its several variations, requires great skill to obtain a satisfactory marginal fit and contour when done directly in the mouth. When constructed on a die, the achievement of a similar result is simplified, but the effort can be surpassed by a cast crown constructed on the same die. The full cast crown can be constructed by either the direct or indirect procedures, or by a combination of them. The direct method is a difficult procedure, requiring skills that the average dentist does not possess. To adapt wax to a full crown preparation in the mouth, keep it adapted to the complete margin, carve and contour it, and avoid distortion through removals and handling, seems well-nigh impossible. The fitting of the casting, and the checking of margins in the mouth are dependent upon tactile skill alone if the preparation is extended below the gingival margin.

Combinations of direct and indirect procedures are used, and usually give a result based primarily on the indirect procedure. One method which is direct in establishing marginal fit, and indirect in creating the other relations of the crown, is one where a copper band is fitted as accurately as is possible in the mouth, and then filled with modeling compound to complete an impression from which to fabricate a die. The fit of this band is duplicated in the finished crown. No attempt is made to improve it by accurately impressioning the actual margin of the preparation. This is, in effect, converting the banded crown to cast, and does not produce an improvement in marginal fit over the banded crown. The indirect procedure introduces additional steps that are potential sources of error, but if carefully executed these errors may be avoided.

A conventional indirect method attempts to secure an accurate impression of a full crown preparation on a tooth, by confining a plastic impression material and registering an exact negative of this preparation. From this negative, a positive, in the form of a die, is constructed. This die is then properly related in casts of the dentition and a cast crown is constructed upon it.

TOOTH PREPARATION FOR CROWNS

I believe that the indirect is the method of choice, and that details of this procedure are very important and contribute greatly to the success of the operation. The proper preparation of the tooth is the fundamental basis for good crown con-

struction, and it is a difficult procedure requiring great skill. The requirements of a good preparation are as follows: (1) There should be adequate occlusal reduction to permit thickness of metal to protect the tooth, withstand occlusal wear, and allow harmonious occlusal relations. (2) Optimal occluso-gingival height and parallelism of axial surfaces should be provided to give sufficient retention and resistance form. (3) Axial surfaces should be reduced sufficiently to provide strength in the crown and to permit establishment of optimal contour of the completed crown. The axial surfaces should be prepared so that they will draw when combined with other preparations, and should be finished smoothly and without undercuts. (4) The preparation should have a definite, regular finishing line placed at an even depth under the free gum margin.

There are pitfalls to be encountered in the full crown preparation and every effort should be made to avoid them. The overreduction of teeth is common and may be attributed in part to the inability of the operator to *see* the area on the tooth being reduced by the instrument. Contending with conflicting pressures, such as those applied to the dentist's hand or instruments by the patient's tongue, lips, and cheeks, and forces used by the dentist to counteract these pressures and to cause the instrument to cut, may result in excessive reduction of the tooth. The use of fast-cutting abrasives and high engine speed reduces tooth structure rapidly. This overreduction in a pulpal direction results in unnecessary loss of tooth structure and encroachment on the pulp, loss of retentive form of the preparation, the production of undesirable shoulders and ledges which are difficult to record in the impression and to fit, and in irregular surfaces. When the overreduction is extended too far below the free gum margin, it causes irregular margins, overextended margins, and severance of the gingival attachment to the tooth. Another pitfall is the production of undercuts that resist the making of the impression, and prevent accurate seating of a crown. All are the result of an improper application and inclination of the cutting instruments.

INSTRUMENTATION

These hazards may be avoided by definite technique and precise instrumentation. The method I use is based on a few underlying principles. To produce axial surfaces that are not irregular and undercut, all instruments used have cutting surfaces that produce straight or plane cuts, and these instruments are applied so as to produce a cut parallel to a common axis. Usually this axis is perpendicular to the occlusal plane. If all cuts on all preparations are straight and perpendicular to the occlusal plane, they will be parallel to each other, and the preparations will draw individually and together. For instance, if a flat disc with a straight handpiece mandrel is used, its cutting surface is at right angles to the shank of the handpiece and, if the handpiece is held in a plane parallel to the occlusal plane, all cuts produced will be perpendicular to the occlusal plane and will be parallel. If a cylinder with the cutting surface on the side is used, and is applied to the tooth with its shank held perpendicular to the occlusal plane, it will produce cuts that are parallel to cuts made by the disc. In the preceding statements "parallel" is assumed to mean approximately parallel, but with a slight convergence toward the occlusal plane to produce a slight taper that will permit seating and withdrawal

of the crown. If tapered stones are applied with their shanks perpendicular to the occlusal plane, and with the tapered end pointing gingivally, cuts will be produced that favor "drawing" of the preparation.

Instruments held as described will produce cuts that are in harmony with the path of insertion of the crown, but if conventional instruments are used, the amount of cutting must still be carefully controlled. Self-limiting diamond instruments (Fig. 3) have helped materially in easing this phase of instrumentation,

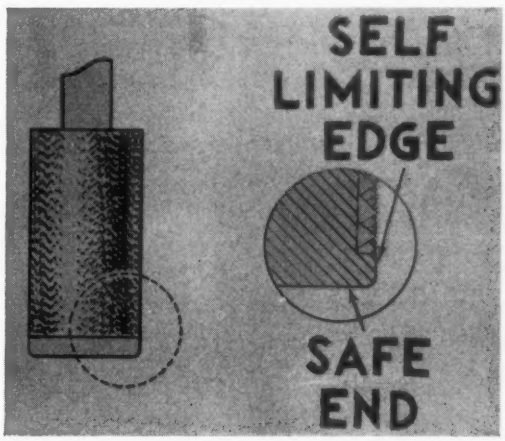

Fig. 3.—A self-limiting diamond cylinder.

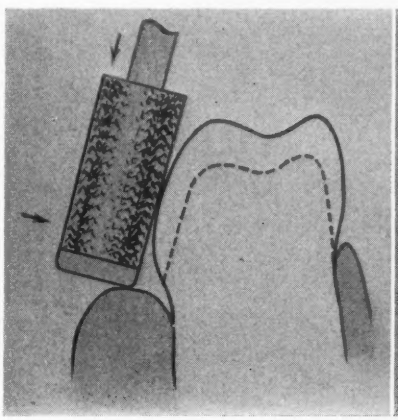

Fig. 4.

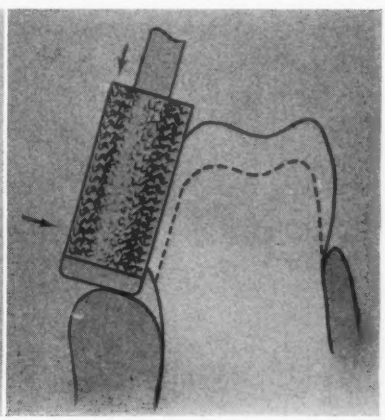

Fig. 5.

Fig. 4.—Application of the cylinder to the tooth. Arrows indicate the direction of pressure.
Fig. 5.—Cutting continued. Note the compression of the gingival tissue.

and have eliminated the danger of overreducing tooth structure on axial surfaces of the full crown preparation. The self-limiting diamond instrument differs from the conventional diamond instrument in that it has a smooth end or edge that can be pressed against the gingiva, a rounded junction between the smooth end or edge that avoids laceration of the gingival tissue, and a smooth guiding edge adjacent to the cutting surface that limits the depth of cutting (Fig. 4). It is obvious

that when the self-limiting cylinder, for instance, is held at the proper angle, the abrasive surface of the instrument will cut the convex surface of the tooth that it is touching (Fig. 5), and that if cutting is continued at this angle, the tooth surface will be reduced in a straight line parallel to the axis of rotation, and that when cutting has continued to a depth where the limiting surface of the instrument starts to touch the tooth, this limiting surface will prevent further cutting into the tooth (Fig. 6). This is a principle long used in industry, e.g., the plow plane, the flanged railroad wheel, the automobile body finishing discs. It will be seen that this eliminates the possibility of overcutting axially, and prevents the formation of undesired shoulders or ledges. By pressing the smooth end of the instrument against the gingiva, the latter is compressed, and the instrument can be placed so that the edge of the abrasive surface can be carried to a point that would normally be in the gingival crevice. At the same time, the width of the limiting surface ensures against cutting to the gingival attachment. The gingiva thereby controls the cutting of the instruments vertically, and the limiting edge controls the cutting axially and pulpally.

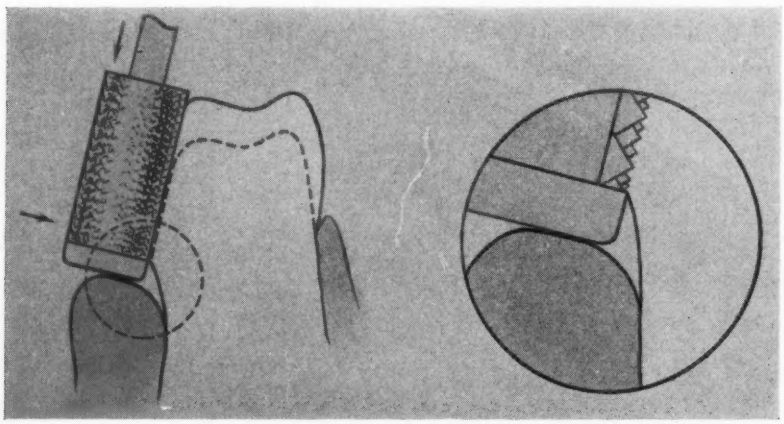

Fig. 6.—The cutting action is stopped by the limiting surface contacting the tooth.

The advantages of the self-limiting instruments are numerous, for they prevent overreduction of tooth structure, the establishment of undesired ridges, shoulders and irregularities; and they prevent the extension of margins to greater depths below the gingival margin than is desired. Less skill and diligence is required to produce a satisfactory tooth preparation because the self-limiting feature of the instrument stops cutting automatically. This stopping is experienced *tactually,* and less dependence upon visual perception is required. These are definite advantages for the older and more experienced dentist. The disc-type instruments greatly reduce the amount of trauma to gingivae, tongue, and cheeks caused by conventional discs. The stone-type instruments, although pressed against the gingivae, do not lacerate or abrade these tissues. The preparation produced, because of the ability of the instruments to follow the tooth contour at the gingival region, is smooth and has few irregularities. The finishing line is definite, unbroken by irregularities, and is superior for fitting. The control of the instrument is easier

because any conflicting pressures that would cause overreduction of the tooth are resisted by the non-abrasive portion of the instrument. All of these advantages combine to eliminate operational tension for the dentist.

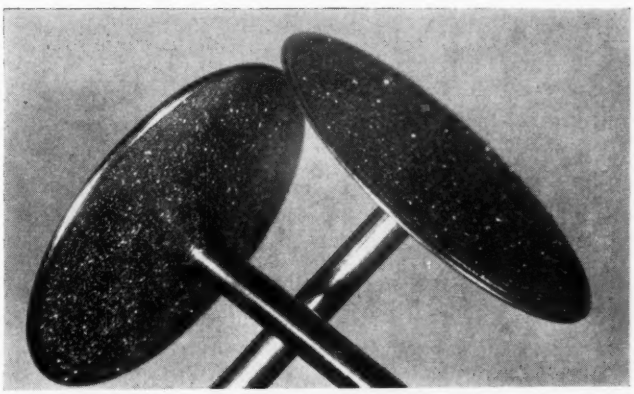

Fig. 7.—Self-limiting discs.

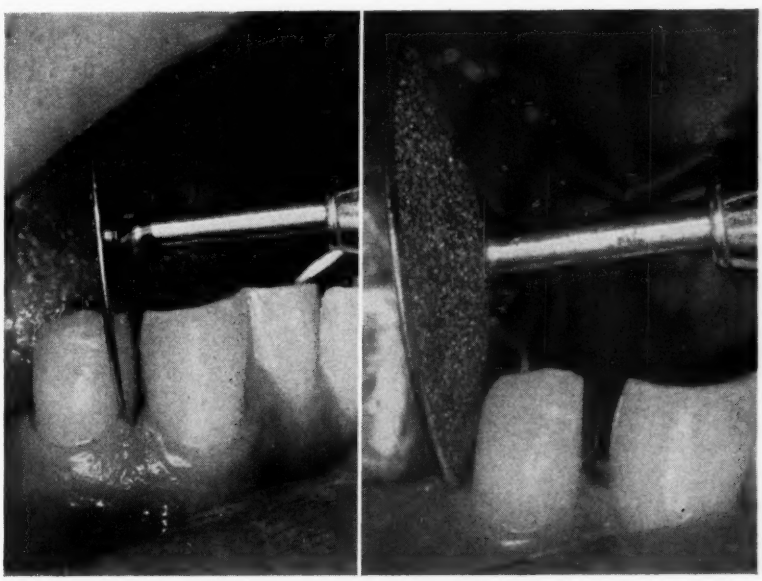

Fig. 8. Fig. 9.

Fig. 8.—The mesial cut. Note the disc margin pressing into the gingiva without laceration.
Fig. 9.—The distal cut is made by use of a cup-shaped disc.

TECHNIQUE OF PREPARATION

The steps in the preparation of a tooth for a full crown are: First, the mesial slice is started by cutting from the occlusal surface through the contact with an edge-cutting disc so as to avoid cutting the adjacent tooth, and to provide space for the introduction of the self-limiting flat disc (Fig. 7). The self-limiting disc is then applied to the tooth (Fig. 8) with the edge of the disc pressing into the

gingival crevice, and the abrasive face of the disc contacting the mesial surface. Cutting is continued (maintaining the handpiece parallel to the occlusal plane) until the limiting edge stops the cutting action, and the disc can be felt to be running freely. The cutting of the surface is carried as far buccally and lingually as the contact of the adjacent tooth will allow.

The second step is the reduction of the distal surface of the tooth, and the instrumentation is the same except for the possible substitution of the cup-shaped self-limiting disc (Fig. 9) for the flat disc.

The third step is the reduction of the occlusal surface, and the gross reduction of buccal and lingual surfaces with a conventional wheel stone. The occlusal surface is reduced following the general planes of the cusps and with sufficient depth to permit adequate thickness of gold to resist wear. The buccal and lingual tooth structure is reduced with a rapid cutting wheel so as to reduce the amount of cutting required of the finer grit, self-limiting finishing stones.

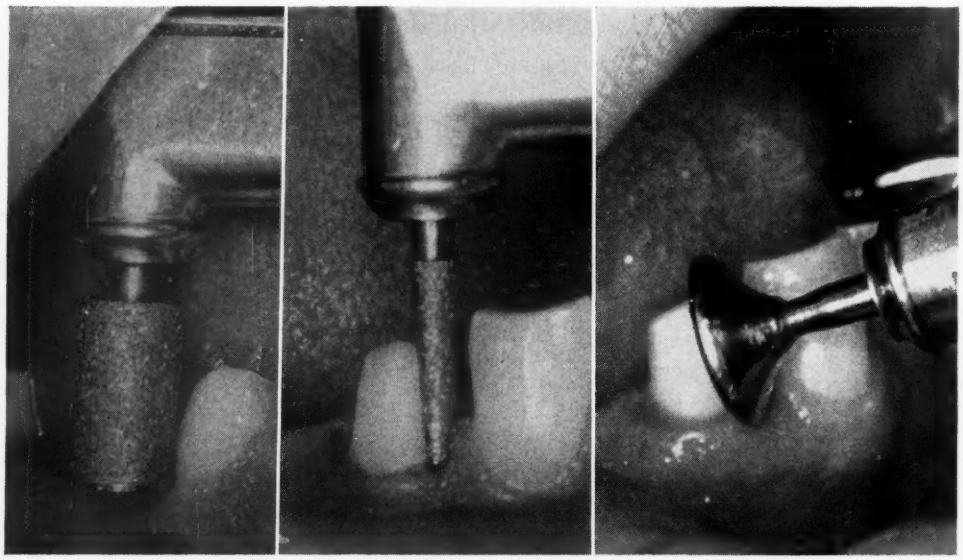

Fig. 10. Fig. 11. Fig. 12.

Fig. 10.—Buccal reduction. Note the relations of the self-limiting edge to the gingiva.
Fig. 11.—Rounding the angles by using a self-limiting diamond tapered point.
Fig. 12.—Rounding the angles by using a self-limiting diamond inverted cone.

The fourth step is the continued reduction of the buccal and lingual surfaces, and the extension of the preparation on these surfaces below the gingival margin (Fig. 10). The large cylinder, self-limiting stone, is held with the shank perpendicular to the occlusal plane, as it is applied against the tooth and the gum. Cutting is continued by moving the instrument over these surfaces as far as the contact area of adjacent teeth will allow, and until no cutting resistance is felt and the instrument rides freely. Smaller-size cylinders are substituted for the large one, and cutting is continued as far interproximally as the contact area permits.

The fifth step is the completion of the preparation by rounding the line angles by using the self-limiting tapered point (Fig. 11) or the end-cutting self-limiting cone (Fig. 12).

The finished preparation should present a smooth axial surface that arises from the gingival crevice and blends into the occlusal surface. From the occlusal view, it should present a slight taper from the gingival, and the peripheral outline of the cross-section of the tooth at the level of the gingival margin of the preparation. This outline should be smooth and anatomic. Any deviation or angularity will represent an irregularity in the preparation. The gingival margin should be distinct and symmetrical. Deviations represent irregularities.

THE IMPRESSION

The second basic step for the production of the crown with good marginal fit is an accurate impression of the preparation. An annealed copper band of a diameter large enough to permit a thin layer of compound between the band and the tooth is selected. It should not be so large that it entraps the gingival cuff. This band is contoured to the cross section of the preparation, and its gingival end is festooned to meet the gingival cuff evenly. A small amount of modeling compound is applied and seared in a ring on the gingival end of the band. The band is then seated over the preparation. Care is taken to position the band accurately, i.e., the axis of the band is parallel to the long axis of the preparation, and the festooned margin is in the true circumferential relation to the preparation to which it was fitted. This compound rim is quickly chilled with cool water, the band is removed, and an impression of the finishing line should have been registered. This marginal impression has the advantage of being made quickly, with little inconvenience to the patient or dentist, and it serves as a check of the accuracy of both the preparation and the fitting of the band. If the complete margin is not visible in the impression, the reason for it is ascertained. If the margin is visible in areas, and then passes beyond the end of the band at the edges of these visible areas, it is an indication that the band is not properly festooned. Where the margin is visible, the band is too long and it should be shortened. The impressioning and trimming are repeated (care being taken always to reinsert the band in the same axial and rotational relation) until the full 360° of the finishing line is visible in the impression, and there is an even rim of band below the impression of the line (Fig. 13). The marginal impression should be critically examined also for defects in the preparation. If the margin proves to be angular, it is an indication that the tooth has not been reduced evenly. Reduction may have been in planes, resulting in an angular cross section to the preparation and/or an angular irregularity in the rise and fall of the gingival margin. Either is indicative of an incomplete preparation, and should be corrected by returning to the preparation and blending these angular cuts into a smooth homogeneous surface. The impression procedure is repeated until the desired margin and impression is obtained. The band is then completely filled with softened compound, positioned as before, and seated under pressure to obtain a complete impression of the preparation. After chilling and upon removal, the impression is examined critically for accuracy of margin, freedom from folds and similar defects, and evidence of distortion, before it is accepted.

DIE FORMATION

The third basic step in crown construction is the formation of a metal die (either amalgam or electroplated) from the impression, and the casting of the crown. The base of the die is usually in excess of the impression, and the peripheral bulk should be dressed down flush with the impressioned surface showing on the die. Great care should be taken to remove this excess without injuring the margin of the preparation that is visible on the die. The base should then be tapered toward the apical end, and keyed so that it may be withdrawn and reseated accurately in a cast of the dentition. This cast is formed from impressions made after the preparation of the teeth. The die is further prepared by the cutting of a circumferential groove around the die about 0.33 mm. below the margin of preparation. This is best done by a No. 39 or No. 40 inverted cone bur (Fig. 14). It serves the purpose of acting as a guide in carving the wax pattern, in checking the seating of the crown on the die, and in finishing the crown to the margin.

Fig. 13.—An impression showing the marginal imprint.

THE WAX PATTERN

The wax pattern blank is then built up in excess, and the gingival margin is carved back to the groove in the die. Removal of the blank permits the examination of the interior of the pattern for discrepancies, and for accuracy of marginal fit upon repositioning. The desired contour and occlusion of the pattern is obtained. The marginal wax is contoured a little heavier than desired for the finished crown (Fig. 15). This latter provides bulk that strengthens the pattern and provides sufficient excess of metal to permit finishing.

After casting, any internal imperfections are removed from the interior of the crown and it is seated on the die. If the casting meets the prepared groove on the die, it can be assumed that the casting is completely seated (Fig. 16). An inverted cone bur is then used to mill away the excess length of the casting, and

to bring the margin of the crown to an accurate fit on the margin of the preparation. This is done by reducing a small area of the margin at a time, repeatedly removing the casting from the die to check the progress until the fit is precise.

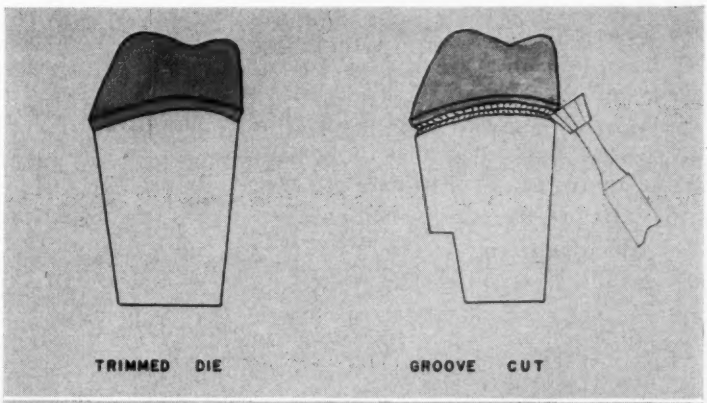

Fig. 14.

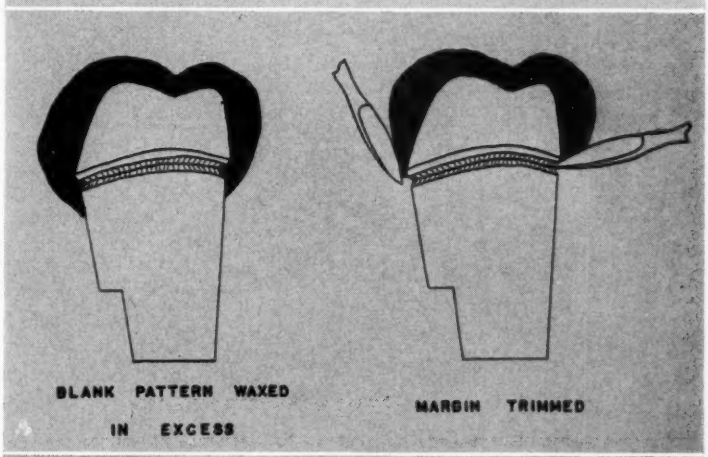

Fig. 15.

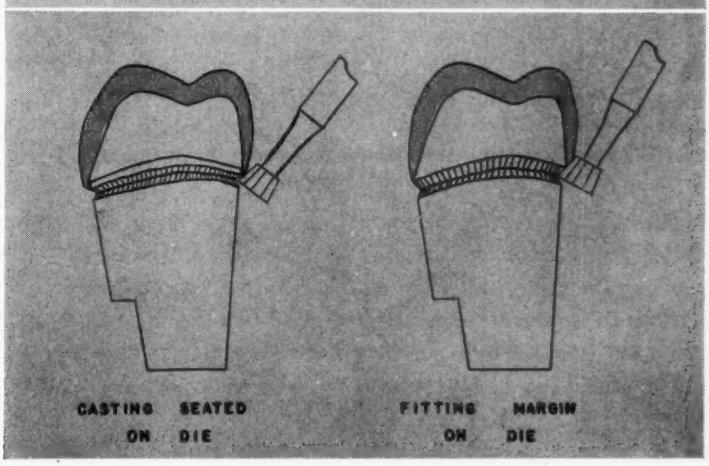

Fig. 16.

Fig. 14.—The preparation of the die using a No. 39 bur to produce a groove.
Fig. 15.—Carving the wax pattern and using the groove in the die as a marginal guide.
Fig. 16.—Milling the crown margin with a No. 39 bur.

This is a procedure that takes patience and meticulous care, but if it is carried out, the results are rewarding. The axial surfaces of the casting are then contoured carefully from the margin and are fitted to contour and occlusion on the cast. The polished crown may then be taken to the mouth for the final fitting.

FITTING IN THE MOUTH

The fourth basic step in achieving a satisfactory crown is the fitting in the mouth. This amounts to a checking of the gingival fit and correction of the contact and occlusion. If the marginal fit is inaccurate, the crown should be discarded and the preparation re-evaluated, corrected if necessary, and a new impression made. Before the marginal fit can be checked, the crown must be completely seated. Excessive contour on the proximal contact areas will prevent the complete seating of the crown. This excess must be reduced, and normal contact must be developed. Final seating may be done by tapping the crown with a steel instrument and mallet. Positive seating may be sensed through the feel and

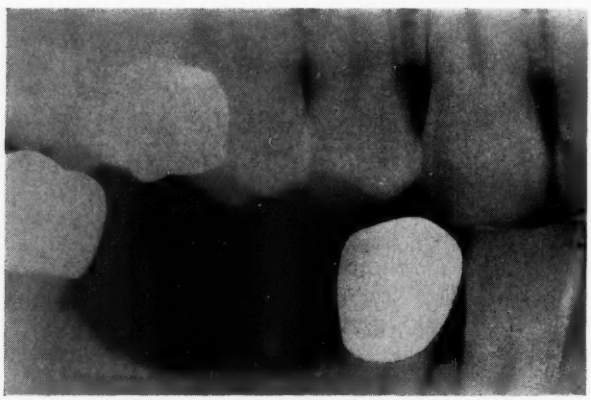

Fig. 17.—Roentgenogram of the crown in place.

ring of the instrument. The margin of the crown may be examined then by using an explorer. An easily accessible point on the crown margin where the preparation margin is readily discernible by tactile examination is selected. With the point directed toward the gingival margin, the explorer is passed over the crown down onto the root surface. If the marginal fit is good, the passage of the point will be smooth. If the passage is interrupted by bumping over a prominence, it means that the preparation is not completely covered, and that the crown is not in place, or that it is short. If the passage is interrupted by the point dropping off of the crown to the tooth, the crown is either too long or not in close apposition with the tooth. A further check of the marginal fit may be made by reversing direction of the point so that it is directed toward the occlusal surface, and is passed from the tooth surface below the crown margin up and over the casting. If the passage is smooth, the marginal fit is good. If the point catches under the margin of the casting, it is an indication that the margin is either too long, or is not in apposition with the tooth. If, in the passage, the point drops over

an irregularity of the tooth, and then contacts the crown, it is an indication that the preparation is not completely covered.

This procedure is repeated at a number of points around the gingival margin, and if any of the above irregularities are evidenced, correction is attempted. The seating of the crown is double checked, overextensions are reduced, and the margins are rechecked. The contour of the crown is checked, and the axial surfaces from the margin occlusally are shaped to be in harmony with the surrounding tissues. If the tactile examination is satisfactory, a bite-wing roentgenogram (Fig. 17) is taken as a check of the interproximal fit, and if this proves satisfactory, the marginal fit of the crown is accepted.

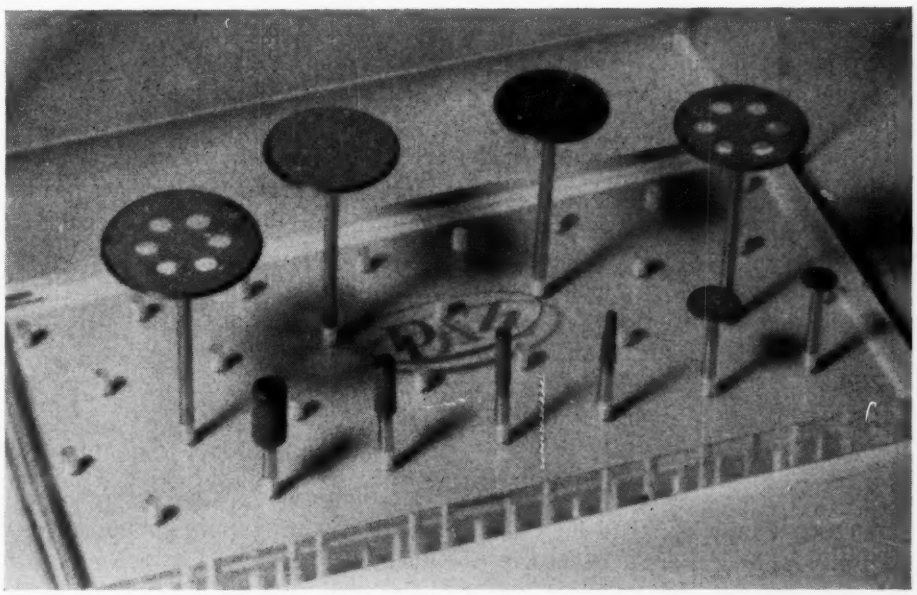

Fig. 18.—The self-limiting instrument assortment used in full crown preparations.

SUMMARY

The construction of cast crowns that possess accurate marginal fit requires: first, understanding; second, ability; and third, conscientious execution. Accordingly, an attempt has been made to present: (1) basic principles of crown construction, (2) a technique of construction with self-limiting instruments (Fig. 18), and (3) methods for evaluating clinical results. Crowns with accurate marginal fit should contribute to the preservation of teeth and the health of surrounding tissues.

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430 West 116th Street
New York 27, N. Y.

MINIMIZING SOLDER JOINT WARPAGE IN FIXED PARTIAL DENTURE CONSTRUCTION

G. J. Perdigon, D.D.S., and E. F. Van Eepoel, D.D.S.

Tampa, Fla.

THE FIXED PARTIAL DENTURE restoration is the method of choice for the replacement of lost natural teeth where it can be used. However, the techniques of construction of fixed partial denture restorations are still open to considerable improvement. Many of the steps employed leave much to be desired. One of the main problems has been in the procedures employed for making the union between the various units of the restoration.

Castings of extreme accuracy can be made for the abutment teeth with our present casting techniques. However, when the restorations are assembled, they frequently fail to go to place. The failure to do so is mainly the result of warpage and consequent loss of relationship between the various parts, during the investing and soldering procedures. The amount of dimensional change which may be attributed to soldering is difficult to determine. However, the presence of dimensional change is readily observed when casts with nonremovable (fixed) dies are used.

The following technique was devised as a possible solution to this problem. The results to date are encouraging and highly promising.

THE TECHNIQUE

A reversible hydrocolloid impression is made of the prepared abutment teeth and the adjacent structures.[1] A master cast made of a hard stone is recovered from this impression. After the gingival area of the abutment teeth on the master cast is exposed, the cast is duplicated by means of a reversible hydrocolloid. The duplicate cast is mounted on an articulator (after the necessary records are obtained). Individual dies of the abutment teeth are obtained from the master cast (Fig. 1). The individual dies and the abutment preparations of the mounted cast are well lubricated in preparation for the making of the wax patterns.

Softened inlay wax is pressed onto the prepared abutment teeth of the mounted cast. The articulator is closed to obtain centric occlusion and to establish the contact areas. The wax patterns are contoured in relation to the adjacent teeth, after which the occlusal surfaces are carved to establish balanced occlusion. The wax patterns are then removed and placed on the individual dies. The contouring and burnishing of the margins of the patterns are completed on the dies.

The wax patterns are returned to the abutment teeth of the mounted cast. A plastic or wax "button" is placed on the side of the pattern next to the pontic

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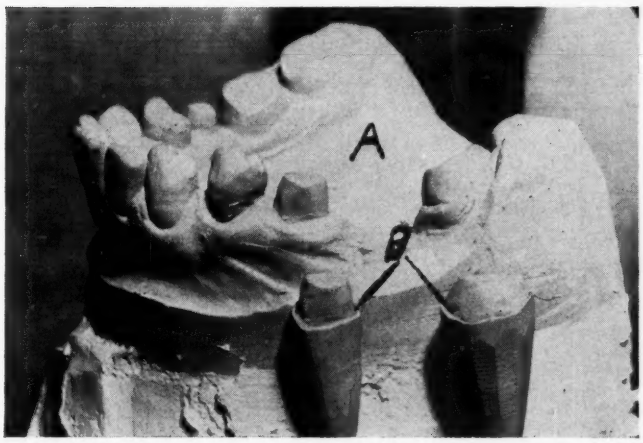

Fig. 1.—*A*, The mounted cast. *B*, The individual dies.

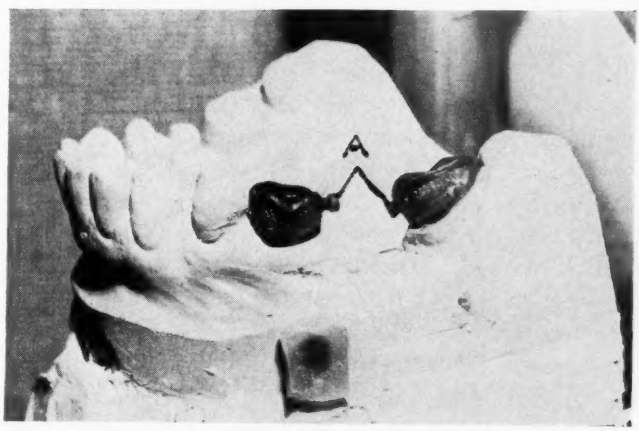

Fig. 2.—The wax patterns of the abutment restorations with the plastic button (*A*) attached.

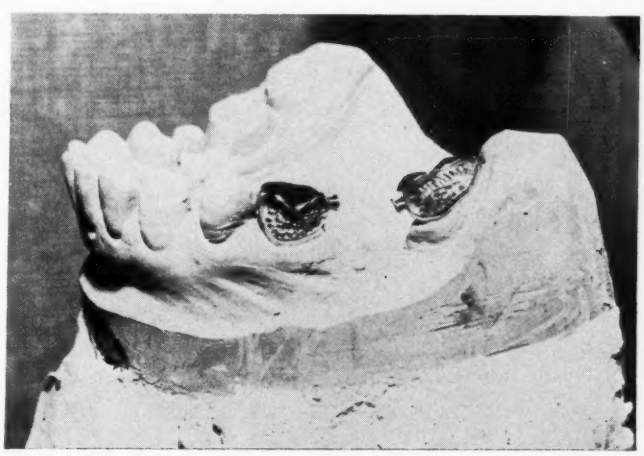

Fig. 3.—The abutment castings on the mounted cast. Note the gold buttons on the castings.

tooth (Fig. 2,*A*). This button should be of sufficient size and have enough undercut to support the wax pontic. The button should be placed high on the pattern to afford clearance around the cervical region, yet it should not interfere with the occlusion. The wax patterns are again returned to the individual dies to refinish and reburnish their margins. The patterns are then sprued, invested, and cast by the hygroscopic technique.

The abutment castings are fitted to the individual dies to check the margins, and then fitted to the abutment teeth of the mounted cast to check the occlusion and contact areas. All surfaces except those immediately surrounding the button are polished.

The castings are reseated on the abutment teeth of the mounted cast (Fig. 3). The surface of the cast where the pontic is to be built is lubricated. Softened wax is pressed to place, and the pontic is carved to proper size and occlusion. Care should be taken to make sure that the wax pontic is well secured to the buttons on the abutment castings. The buccal surface of the pontic is hollowed out and carved to insure proper retention for an acrylic resin facing.

CASTING THE PONTIC

A 14 gauge round plastic sprue is attached to each casting, and a 12 gauge sprue is attached to the wax pontic. All three sprues are connected together (Fig. 4). The castings and the wax pontic, with sprues attached, are carefully removed from the cast, and invested by the hydroscopic technique. After the investment is set, the ring is heated and the pontic is cast. It is important that the casting is made at between 850° and 900° F.

After the casting is made, the assemblage is placed on the mounted cast and examined for correct seating (Fig. 5). If satisfactory, the assemblage is removed from the cast, the joints are fluxed, and a small piece of solder (approximately 2 mm. long and 1 mm. wide) is placed at the junction of the pontic and the button of the abutment casting. The assembled appliance is held over an open Bunsen burner flame and heated until the solder flows (Fig. 6). It will be found that the solder will fill the most minute discrepancies at the joints. The entire bridge is then allowed to bench cool.

The gold sprues are then cut away, and the bridge is reseated on the mounted cast. The occlusion is adjusted if necessary. The acrylic resin facings are then processed in the restoration (Fig. 7).

SUMMARY

By means of the technique described, the procedure of investing for soldering is eliminated. A minimum amount of solder is used, and the possibility of dimensional changes during soldering procedures is thus reduced.

To date, eighty fixed partial dentures have been constructed by this technique, with only one failure. The failure was attributed to a faulty impression, since it was repeated with the same preparations, and a satisfactory result was produced. The technique has been used for appliances varying from two units to complete mouth reconstruction (Fig. 8).

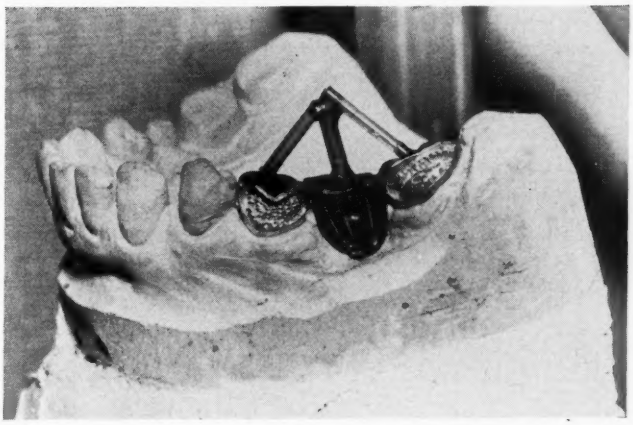

Fig. 4.—The sprues are attached to the castings and to the wax pontic so that they are connected together.

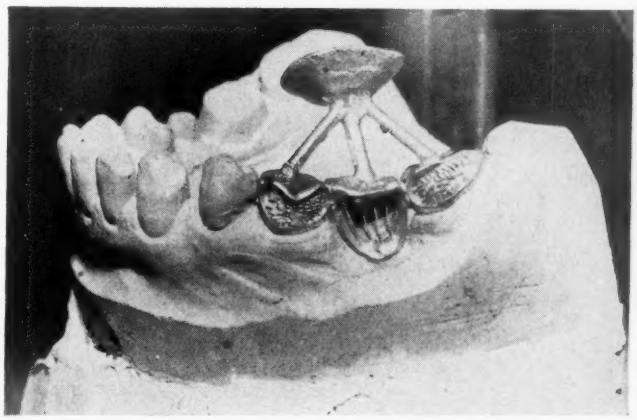

Fig. 5.—The completed castings seated on the mounted cast.

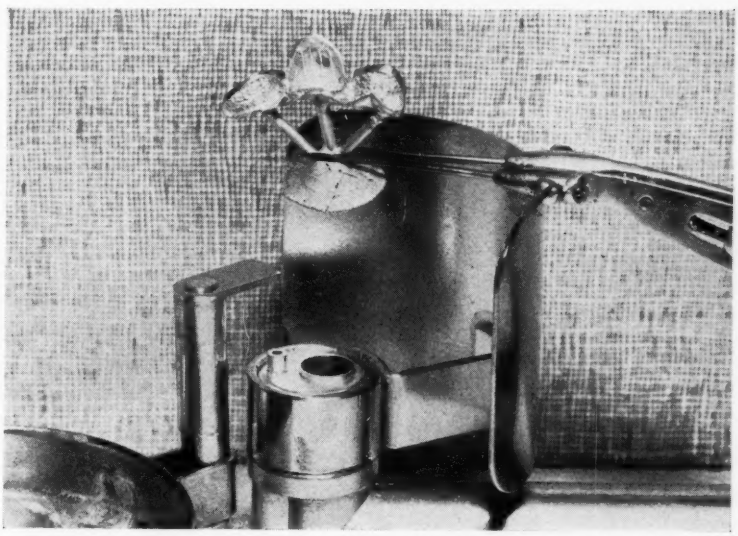

Fig. 6.—The assembled appliance is soldered over the Bunsen flame with the sprues still attached.

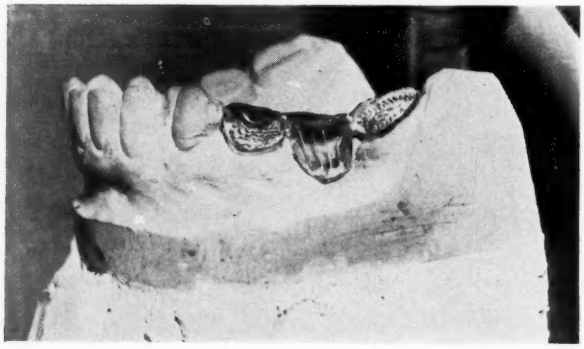

Fig. 7.—The appliance is ready for the processing of the acrylic resin facings.

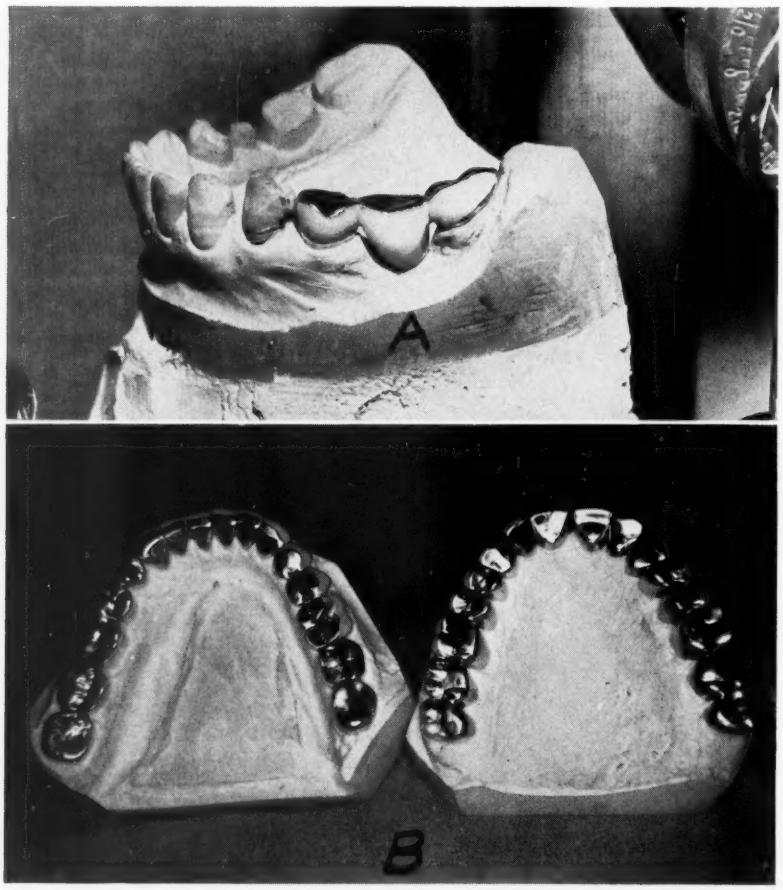

Fig. 8.—Restorations assembled by this technique. *A*, A three-unit fixed partial denture. *B*, A complete mouth reconstruction.

We wish to acknowledge indebtedness to our technician, Mr. Glen Wakefield, for his attention to the details which made the description of this procedure possible.

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17 Davis Blvd.
Tampa, Fla.

PORCELAIN INLAYS BETWEEN ANTERIOR TEETH WITHOUT SEPARATION

GEORGE T. GREGG, D.D.S.

Pittsburgh, Pa.

ONE OF MY PROBLEMS has been to place porcelain inlays between the anterior teeth without much tedious work and inconvenience to my patient. For that reason, I have placed fillings about which I was not happy. I have overcome this problem by a technique which requires the minimum of tooth separation.

No special skill is required, and those who do not do their own porcelain work can produce accurate dies for a laboratory. Ninety-eight per cent of the cases do not require separation, and five-thousandth of an inch of separation is sufficient (about the thickness of writing paper), if it is necessary.

THE EQUIPMENT

1. A rubber dam punch.
2. A springy matrix metal* 0.005 inch thick, with enough elasticity to restore its original form if bent.
3. One of the rubber base impression materials.
4. Coe-flex liquid.
5. Tissue tin.†

CAVITY PREPARATIONS

Porcelain inlays can be used in four types of cavities: labial, proximal, proximal-labial combination, and incisal corners (Fig 1).

Proximal cavities should be prepared as nearly box-shaped as possible, with the opening slightly wider than the base so the impression can be withdrawn. Incisal corners can have a substantial lock on the lingual surface for retention.

IMPRESSIONS

All impressions are withdrawn labially or lingually, i.e., at right angles to the long axis of the tooth.

To make an impression of a cavity between any of the six anterior teeth, shape a piece of the 0.005 inch metal, about ½ inch long and slightly (1.0 mm.) wider than the cavity (Fig. 2).

Presented as a table clinic before the American Academy of Restorative Dentistry, Chicago, Ill., Feb. 4, 1956.

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*William Dixon, Inc. 32 Kinney St., Newark, N. J.

†Obtained from J. M. Ney Company.

With the rubber dam punch, punch three or four small holes in the metal so that, when the metal strip is placed between the teeth opposite the cavity, the holes will be about its center. The object of the holes is to secure the impression material firmly to the metal strip, by flowing through the holes. This makes it possible to remove the impression. To further secure the impression material to the metal strip, paint on the cavity side of the metal with a thin film of Coe-flex. It should be thinned so the film will be quite thin.

The impression procedure is quite simple. Some half-inch squares of the thin tin are prepared in advance, to prevent the impression material from sticking to the finger while it is being forced to place. Lubricate the cavity with a 10 per cent solution of Aerosol. This will reduce surface tension and prevent bubbles in the impression.

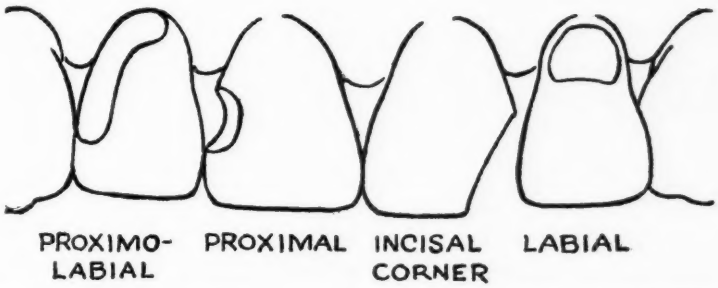

Fig. 1.—Various types of cavities which may be restored by porcelain inlays.

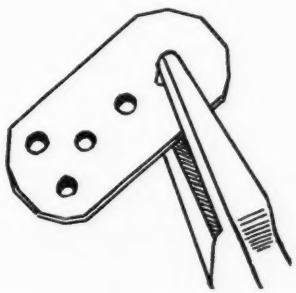

Fig. 2.—Thin steel is perforated to act as a tray.

The perforated metal strip should be flat so it will be easy to slip between the teeth, and so it can be withdrawn without being bent or distorted. Place the metal strip in position between the teeth (Fig. 3). Mix sufficient rubber impression material (Permlastic), and with a suitable plastic instrument tease the Permlastic into the cavity. Be careful not to disturb the perforated metal strip. Add extra impression material against the metal strip. Place a square of the thin tin on the excess material, and press gently against the tin square with the index finger until the impression material rolls 1.0 mm. over the margin of the cavity on the side opposite that from which the impression is to be withdrawn. For example, if the impression is to be taken out on the lingual side, press the material so it will just roll over the margin on the labial side.

The impression material sets in about four minutes. Setting can be hastened by heating a wet pellet of cotton placed on the square of tin with a large ball burnisher. When the impression material loses its stickiness, the impression can be gently withdrawn.

When the cavity is large, and opens from lingual to labial, such as an incisal corner, dry the laxial surface, and paint it with a sticky cavity lining (gum mastic dissolved in chloroform). Then cover the surface with 24 gauge Kerr soft blue wax. Cut the wax away from the cavity margin about 1.0 mm. The wax will prevent the overflow of the excess on the cavity margin.

For developing the contact area of an incisal corner restoration with an adjoining tooth, make an impression of both teeth with the rubber impression material. No fitting in the mouth will be required and the fit will be surprisingly accurate.

The proximal labial cavity (Fig. 1) requires the use of a metal strip between the teeth, and one shaped to fit the curvature of the labial surface and rounded so it will pass beneath the gum margin (Fig. 4).

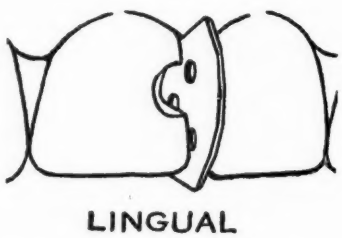

Fig. 3.—The perforated steel plate in position for making an impression of a proximal cavity.

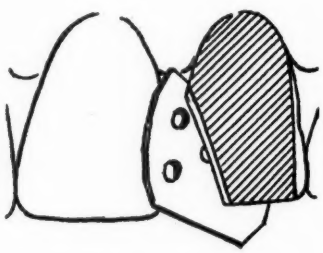

Fig. 4.—The perforated steel plate and the labial steel plate in position for making an impression of a Class IV cavity.

With the perforated metal strip in place between the teeth, fill the cavity with rubber impression material, add some of the material to the metal shaped to fit the labial surface, and pass it beneath the gum margin. Then place the tin square in position and press it to place. Hold it in position for about one minute, then fit a short piece of copper wire to the angle formed by the two pieces of metal, and with sticky wax place the wire in the angle. The wire prevents distortion when the impression is withdrawn.

To make impressions of Class V cavities (Fig. 1) at the gum line, shape the perforated metal to the curvature of the labial surface of the tooth so it will pass beneath the gum margin. Lubricate the cavity, blow away the excess moisture, and fill the cavity with rubber impression material. Place some of the material on the metal, and slide it beneath the gum margin. Place a tin square over the perforated metal and press it to place.

If the gingivae interfere, the gingival crevice can be packed with Sensitex on cotton to make space for the metal. The Sensitex should be neutralized with bicarbonate of soda.

It is important to groove the cavity after the impression is made, and to do the same to the filling. In this manner, a lock is created which will help to prevent dislodgment of the filling.

DIES AND MATRICES

The impressions should be filled with a model cement.* Any thin edges should be re-enforced so as to prevent their crumbling during the swaging of the platinum matrix.

When the cement model is invested in modeling compound which is contained in a metal cup for swaging, the platinum is gently shaped to the cavity with orange-wood points, then forced to place in the swager.

Illustrations are by Dorothy Sterling.

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Pittsburgh 22, Pa.

*Caulk's Model Cement or Posterior Di-Cem.

FILLING A CLASS V CAVITY WITH A COMBINATION MAT AND COHESIVE GOLD FOIL

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Omaha, Neb.

FOR MANY YEARS it has been the goal of the dental profession to try and find the perfect filling material for the restoration of anterior teeth. As of today, this has not been accomplished. There are people to whom the saving of their teeth is more important than a perfect esthetic appearance.

When the plastics became available, some thought the perfect filling material had at last been found. The day might come when this may prove to be true. It is not true today. While the scientists are working on the perfect esthetic material, let us keep on saving teeth with the one material which will do the job better than anything that has been tried up to this time. What but gold foil could save teeth for 67 years, as was recently vouched for by a prominent gold foil manufacturing company?*

A prominent dentist recently remarked, "There is no competition for good dentistry." A good gold foil operator is likewise a good dentist. There is something about being a gold foil operator—he never seems to be satisfied with the dentistry he is doing, but he is continually trying to improve his operations in other branches of dentistry.

One of the principal benefits derived from being a gold foil operator is that it requires the use of the rubber dam. I know that most patients do not like the rubber dam. However, if it is explained that the work can be done better, quicker, and under more sanitary conditions, very few will object, and once the operator becomes accustomed to its use he will not be satisfied to work without it. A friend of mine says that he uses it so that, "He can see what he is doing and do what he is seeing."

A cavity prepared with the rubber dam in place, and filled with gold foil fresh from the flame in a completely sterile condition constitutes the most surgically clean operation in dentistry.

PROPERTIES OF FILLING MATERIAL

The properties most desirable in materials for permanent operations have been listed by Black[1] as: "(1) indestructibility in the fluids of the mouth, (2) adaptability to the walls of the cavity, (3) freedom from shrinkage and expansion after

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*Morgan-Hastings.

having been placed in tooth cavities, (4) resistance to attrition, and (5) sustaining power against the forces of mastication."

The qualities of secondary importance include: (1) color and appearance, (2) nonconductivity of thermal impressions, and (3) convenience of manipulation.

In the filling of a Class V cavity, it is agreed that gold foil meets most of the desirable qualities for a filling material and, as our techniques and skill advance, we are overcoming more of the undesirable qualities of gold foil as a restorative material for the restoration of lost structure in the interproximal surfaces of the anterior teeth.

Building a gold foil restoration is not an easy operation for either the patient or the operator. Therefore, we should make it as easy as possible for both. The proper seating of the patient in the chair, and the adjustment of the chair to the patient will greatly minimize the discomfort of the operation. A soft pillow on the headrest, and a larger one at the small of the back will make the patient more comfortable. If the patient is inclined to be nervous, sedation is very helpful both psychologically and physically. Local anesthetics are almost essential, because without them it is hard on both the patient and the operator.

THE RUBBER DAM

The patient's objection to the rubber dam can be greatly minimized by its careful and efficient application. Many little things can be done to reduce the patient's discomfort, such as placing a rubber dam napkin between the dam and the patient's face. If the clamp is on a posterior tooth, the release of the corner of the mouth by turning the lip back with the finger just prior to adjusting the dam holder is a relief. The proper selection and adjustment of the clamp is important. A clamp should seldom be used except on molars, and possibly on the lower bicuspids. In most other instances the dam can be retained by using a bead on a ligature. The ligature is tied so the bead will be in the interproximal space at the distal surface of the last tooth exposed by the dam. Ligatures should be used as sparingly as possible, and often none are needed. In passing the ligature past the contact areas to help carry the dam to place, the ligature should be held so that there is a short piece of it between the fingers, and it should be stretched tightly as it is passed through the contact area at an angle.

A neat application of the rubber dam adds to the appearance of the field of operation, and enhances the chances for a better, neater operation. After the dam is in place, the teeth are washed with grain alcohol to make the field of operation as clean and sterile as possible.

In making a Class V restoration, it is necessary to use a special clamp to retract the gum tissue. For this purpose, the S.S. White No. 212, designed by Dr. W. I. Ferrier, is the most efficient. It is a weak clamp, and the jaws are not sharp so it does not dig into the cementum. Therefore, it must be fastened in position with modeling compound. After the teeth are washed with alcohol, the remaining mucin is removed with hydrogen peroxide. The exposed teeth are dried with air. When modeling compound is to be attached to the exposed teeth, the surfaces on which it is to be placed are painted with Copalite.

Two small slits made in the gum will allow it to be held back on retraction. This is better than stretching the gingival tissue and causing strangulation of it. Therefore, one cut about 2 or 3 mm. long is made in the gingival tissue on the mesial and distal side of the tooth. The cuts are separated about the width of the required restoration. They can be made either before or after the rubber dam is in place. The rubber dam is stretched back, and the clamp is placed in position so that it will expose the tooth beyond the area to be restored and is secured in place with green-stick compound.

CAVITY PREPARATION

The outline of the cavity is governed by the caries and the decalcified or eroded area. The mesial and distal margins of the preparation are placed inside of the corresponding angles of the tooth, unless caries or decalcification carries it beyond the angles. Then it should be extended to the margin of an interproximal restoration or to the place where a margin of such a restoration would be. The gingival margin is usually carried below the gingivae, and the incisal or occlusal margin is placed so as to include the caries or decalcified area. The retention is placed in the gingival and incisal or occlusal wall; never in the proximal walls. It is made with a No. 33½ inverted cone bur, and sharpened with an angle former. The cavity is varnished, to prevent thermal shock, before the margins are beveled. This will make sure that no varnish is on the margin.

FILLING MATERIAL

Mat gold consists of electrolytic deposits of millions of particles of gold. Gold foil is made by a beating process, therefore, it is tougher and will stand drawing or burnishing. Mat gold being made as it is, does not stand the drawing or burnishing without fracturing; neither does it stand being forced into the undercuts to fill the retention as well as gold foil. From all appearances, the mat gold can be used to facilitate filling the cavity except in the retention, and in the final filling of the cavity and covering of the margins. According to Rule,[3] "mat gold when malleted, has an average hardness and is only slightly below average in density to gold foil."

PREPARATION OF GOLD

To make gold so it can be stored, it is covered with ammonia gas which makes it noncohesive. Mat gold comes in strips (all wide, assorted, or all narrow), and needs only to be cut to the size desired to be ready for use. Gold foil comes in books containing 12 to 14 sheets, 4 inches square. It weighs 1/10 of an ounce, and must be cut to size and hand rolled. It also comes ready for use in pellets which are machine rolled and cut to different sizes at the factory. While the machine-rolled pellets are less work, the gold that comes in sheets can be made into more different sizes of pellets, and is easier to place into the cavity. Each will make an equally good filling, if properly manipulated.

Gold foil can also be obtained in combination with platinum foil. This is called platinized gold foil. It is made by placing a sheet of platinum between two

sheets of gold foil, and malleted to thinness. It is used only on occluding surfaces as it is much harder and grayer than the pure gold.

ANNEALING OF GOLD

The annealing or driving off the gasses of gold foil can be done either on an annealer, on mica over a flame, or on an electric annealer. It may also be passed through the open flame.

The only objection I have to the annealer is that the gold must be on the annealer for a few minutes before it is ready for use and, if there is any left over, it never seems to handle quite as well after it has cooled and has been reannealed. Annealing gold in the open flame also has its disadvantages, the chief of which is that it is easily contaminated by the flame, or it can be overheated so that it is harsh and does not handle so well when it is condensed. The lighting of the alcohol lamp seems to be the most common cause of trouble. If the lamp is lighted by a match, the match, after it is ignited, is allowed to burn down on the stem and the part of the flame nearest the fingers is brought to the lamp. The sulphur from the head of the match, if allowed to touch the wick, will contaminate the gold which will cause trouble in building the filling.

BUILDING, NOT PLUGGING THE FILLING

In filling a Class V cavity with gold foil, a piece of mat gold is cut as near as possible to the size of the cavity, annealed, and carried to the cavity. It is carefully held into place with the holding instrument, and hand condensed over the entire cavity floor, stepping the instrument from the center toward the cavity margin. It is then condensed with the mallet pressure, stepping the instrument from the center of the cavity toward the margin. Each step of the condenser point must overlap the preceding one. It is very important to watch the stepping of the condenser in order to keep the gold smooth and produce a dense filling. After the first piece of mat gold is condensed and held during the condensation, gold foil pellets (1/64) are forced into the retention. The nature of the gold makes the pellets more desirable for filling the retention points. After the retention points are filled, the holder can be released and the cavity filled just short of full with the mat gold, or both mat and cohesive gold. The line of force is carefully noted, and always directed toward the cavity margins.

The final filling is done with cohesive gold which will form better margins and a better finished surface. The cavity must be overfilled to allow for sufficient gold to finish down and restore the tooth form.

FINISHING THE FILLING

An old carbide bur, with the end rounded with a stone, is excellent to trim the gold to form. The bur in a contra-angle handpiece, and with the engine running very fast and with a very light touch, will trim the filling very quickly. The final shaping of the filling is done with both push-and-pull cut gold knives, and fine extra thin disks. The latter can bend to prevent cutting grooves in the filling and the

tooth. If the push cutting knife is used, the point of the blade is placed ahead of the margin and rested on the tooth. This serves as a guide to prevent gouging into the tooth or the filling.

The final polish is made with extra fine pumice in a rubber cup, and the area is kept cool with a stream of air to prevent overheating the tooth.

SUMMARY

Woodbury[3] summarized gold foil manipulation in 1912 as follows: "There is nothing about the manipulation of gold foil that cannot be acquired by any one whose natural gifts fit him to the practice of dentistry. To be successful, all that is required is the very careful following of a certain technique in all of its details. Any short cut or any compromises are almost always followed by failure. Any one who will master the technique and have courage to follow where ever it leads him need never fear, for the results of his application will be amply satisfying." His summary is still valid.

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FLOW STUDIES OF CERTAIN DENTAL IMPRESSION MATERIALS

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VARIOUS MATERIALS ARE RECOMMENDED and used for making final impressions in prosthetic dentistry. In order to minimize tissue displacement, some operators prefer a material which will flow readily upon insertion, while others utilize a stiffer impression paste to exert a depressing force against the soft tissues. Flow or fluidity of the material seems to be the main criterion for selection.

A few studies have been devoted to the flow of various types of impression pastes. Skinner[1] investigated the fluidity of several of the zinc oxide-eugenol pastes, as well as certain other physical properties. It was found that the eight impression pastes studied differed widely in consistency. More recently, Asgarzadeh and Peyton[2] studied the consistency and flow of pastes when mixed at different ratios and temperatures. It was found that the consistency was influenced to some degree by a change in ratio for some products but, in general, a greater variation in consistency results from changes in temperature and humidity. Nealon[3] investigated the effect of mixing temperature on the flow of the alginates. The tray was positioned at a 45 degree angle, which permitted a study of the flow in one direction. Both the duration and the amount of flow were recorded. In general, both the magnitude and duration of the flow were inversely related to the temperature.

However, many other variables associated with these materials need investigation, and one of the more important clinical considerations is the amount of flow each material exhibits at various times at which it might be placed in the mouth. The purpose of this article, therefore, is to compare the degree of flow obtained with several types of impression materials and to determine the amount of flow to be expected if the materials were placed in the oral cavity at varying times following spatulation. The initial and final set of the materials were also determined for correlation with the flow.

PROCEDURE

Fifteen commercial impression materials of various types were tested (Table I). All were purchased on the open market between the period of Oct. 1, 1955, and April 28, 1956. The manufacturer's directions for manipulation were carefully

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followed. All were mixed at room temperature (78°F. ± 5°F.), and for those materials which required water in the mix, 70°F. water was used. The relative humidity during mixing was between 35 and 50 per cent.

TABLE I

	MANUFACTURERS	BATCH NUMBER
A. *Zinc Oxide-Eugenol Pastes*		
1. Coe-Trans	Coe Laboratories, Inc.	#1011
2. Coe-All-Tec	Coe Laboratories, Inc.	#JJ21
3. Coe-Flo	Coe Laboratories, Inc.	#004
4. Truplastic	Wm. Getz Corporation	
5. Ackrapaste	The Ackerman Dental Mfg. Co.	#53269
6. S. S. White Impression Material	S. S. White Dental Mfg. Co.	#53655252
7. Luralite	Kerr Mfg. Co.	#MM602MM618
B. *Rubber Base Materials*		
1. Permlastic	Kerr Mfg. Co.	
2. R28	Wm. Getz Corporation	#5145
3. Coe-Flex	Coe Laboratories, Inc.	#PP211
C. *Alginates*		
1. D-P	Dental Perfection Co.	#2642, #2650
2. Jeltrate	L. D. Caulk Co.	#311556
3. Coe-Alginate	Coe Laboratories, Inc.	#LL3
D. *Plasters*		
1. Kerr's Impression Plaster	Kerr Mfg. Co.	
E. *Plaster Base Materials*		
1. Plastogum	Harry J. Bosworth Co.	#7086

The flow test used was a modification of the American Dental Association consistency test for zinc phosphate cements,[4] and was similar to the one used by Skinner.[3]

Following mixing, 0.25 c.c. of the impression material was placed in a glass tube. Starting at one and one-half minutes after the beginning of spatulation and at fifteen-second intervals up to a maximum time of four minutes, the mix was ejected from the tube and placed between two glass plates. These plates were then placed in a humidifier at an atmosphere of approximately 100 per cent humidity and held at 98° F. ± 1° F. A 200-gram weight (arbitrarily selected) was placed on the top glass plate. At the end of ten minutes, the weight was removed and the average diameter of the disc of impression material was determined (± 1.0 mm.). The data presented are the mean of a minimum of three individual specimens at each time interval.

RESULTS

Flow.—Flow or stiffness of the various zinc oxide-eugenol impression materials at any time interval varies widely (Fig. 1). This wide range of flow corroborates previous research.[1, 2] It might be pointed out that a flow of approximately 34 mm. represents a very thin material with a tendency to run from the spatula and is difficult to contain in the impression tray. When the flow was only 20 mm., the

material was very stiff, sticking to the spatula. From a purely objective manipulative standpoint, a flow ranging from approximately 25 to 30 mm. was felt to be normal and satisfactory for this type of material.

Generally all of these products exhibited little change in flow as related to the time at which the load was applied. It would seem from these data that working time, within limits, was not critical. A different type of curve was established, however, with two other zinc oxide-eugenol pastes (Fig. 2), both of which had high flow when tested immediately after spatulation but showed marked decrease in flow when the time of application of the load was delayed. This critical time was approximately two and one-fourth to two and one-half minutes after beginning spatulation. The working time with these materials, although adequate, would obviously be limited. Actually, however, the rapidity with which those two products attain their set properties is a greater factor of safety against distortion of the impression.

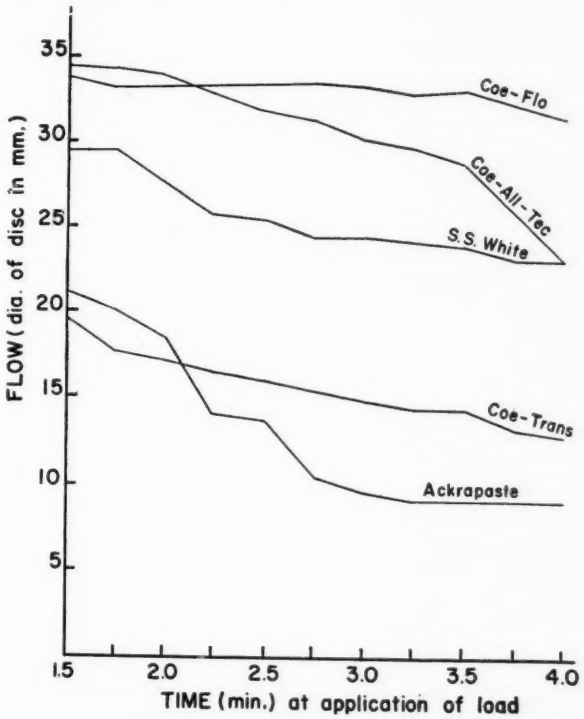

Fig. 1.—Flow of various zinc oxide and eugenol pastes as related to the time of applying the load.

The flow of the three rubber base materials tested (Fig. 3) was comparable to the group shown in Fig. 1. The flow was not greatly influenced by the time interval elapsing between spatulation and application of the load.

The flow of three representative alginates can be seen in Fig. 4. As would be expected, the flow of these materials decreased rapidly with time. Thus, if flow is desired, the time between spatulation and placement in the mouth is critical, more so than with any of the other types of impression materials studied. It must be

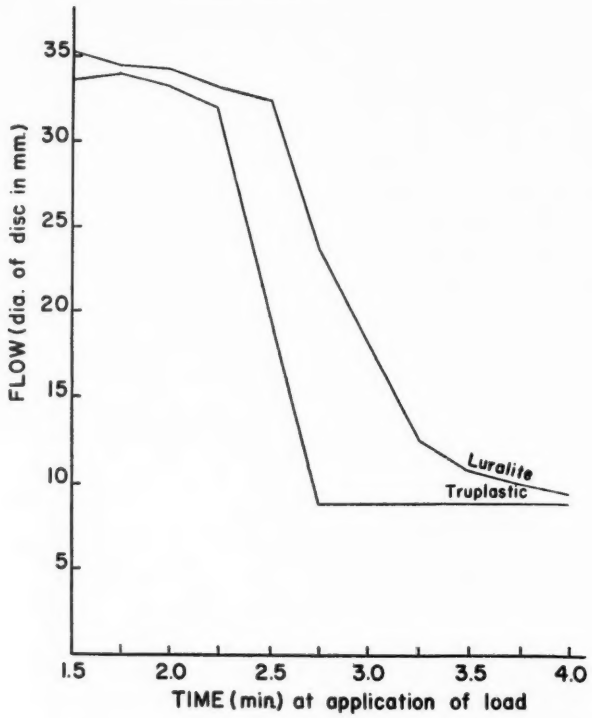

Fig. 2.—Flow of two pastes where the time of load application markedly influences this property.

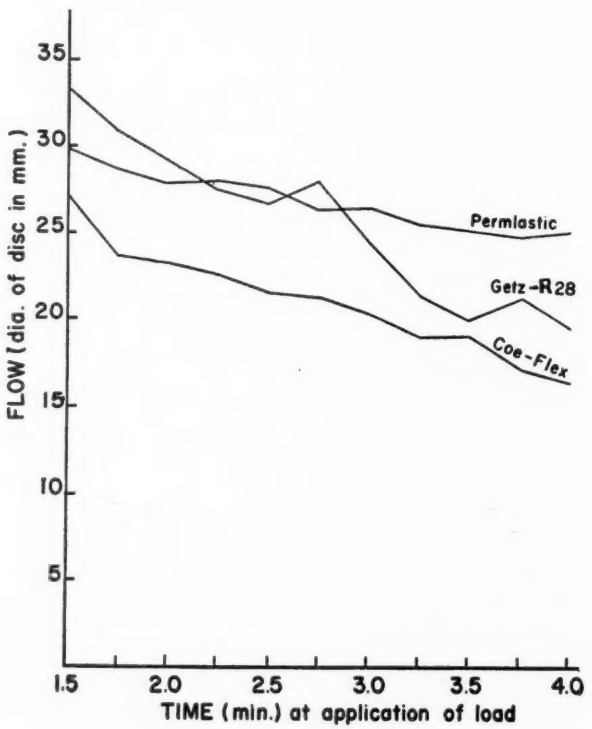

Fig. 3.—Rubber base materials.

pointed out, of course, that 70°F. water was used, and the setting time could be increased somewhat by the use of cold water.

A wide variation of flow was found with the plaster-type materials (Fig. 5). Although the impression plaster was very fluid during spatulation, it rapidly increased in stiffness and at only one and one-half minutes from the start of spatulation it exhibited less flow than all of the materials tested, with the exception of two of the zinc oxide-eugenol pastes (Fig. 1). In contrast, Plastogum was so fluid that, even at one and three-fourth minutes after the start of spatulation, it was difficult to pick up the material with a spatula, and it obviously would also have been difficult to contain in an impression tray. However, it can be seen that with both of these materials, the flow decreases rapidly with time. Again it should be pointed out that 70°F. water was used and that the setting time and the flow of these materials could have been altered by using colder water in the mix. However, this variable was not part of the study.

Setting Time.—It is obvious that the flow of the materials at various time intervals is dependent not only upon the inherent fluidity or consistency but also on the progress of the setting reactions. In order to establish the relationship of setting time to the flow, each material was tested for its initial and final set.

The material was mixed in the same manner as has been described. The method used for measuring setting time was similar to that employed by Asgarzadeh.[2] A ¼ pound Gilmore needle was applied at fifteen-second intervals, measured from the start of spatulation. The impression material was readily penetrated at first and, upon removal of the needle, would flow into and fill the impression made by the needle. The time recorded as the initial set was the time at which the impression material would no longer flow into and fill this impression, and the final set was the time at which the needle no longer penetrated the surface. Practically, both initial and final set are important, since the material must be carried to the mouth before appreciable set has occurred, and must not be removed before the final set. Probably a short time interval between initial and final set is desirable.[3] The data presented are the mean of three tests.

The results can be seen in Table II and may be correlated with the flow values shown in the previous figures. It can be seen that in general there is a definite correlation with most materials—those which showed a marked decrease in flow at the various time intervals also had decreased setting times, and a shorter time interval between the initial and the final set. For example, both Luralite and Truplastic showed a sharp drop in flow at the application of the load between two and one-half and three minutes. Examination of the setting time data shows an initial set close to this figure, and a very short time interval between the initial and final set. On the other hand, the flow of Coe-Flo was not greatly affected by time, and the time of the initial set is, of course, quite long. (Although the technique was slightly different, the data obtained for the rubber base materials compare quite well with that published by Skinner and Cooper.[5])

There are some exceptions, however, to this relationship. Jeltrate and D-P showed a marked reduction in flow before the initial set had been reached. The analysis of the data presented by Asgarzadeh[2] also reveals that there was not always

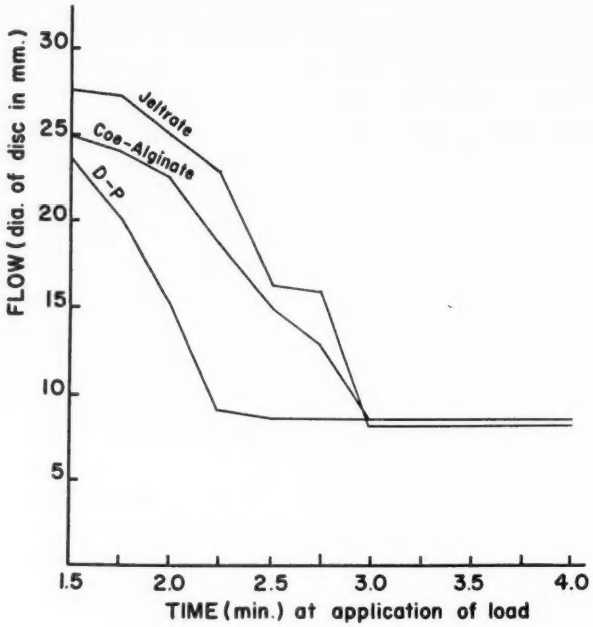

Fig. 4.—Alginates.

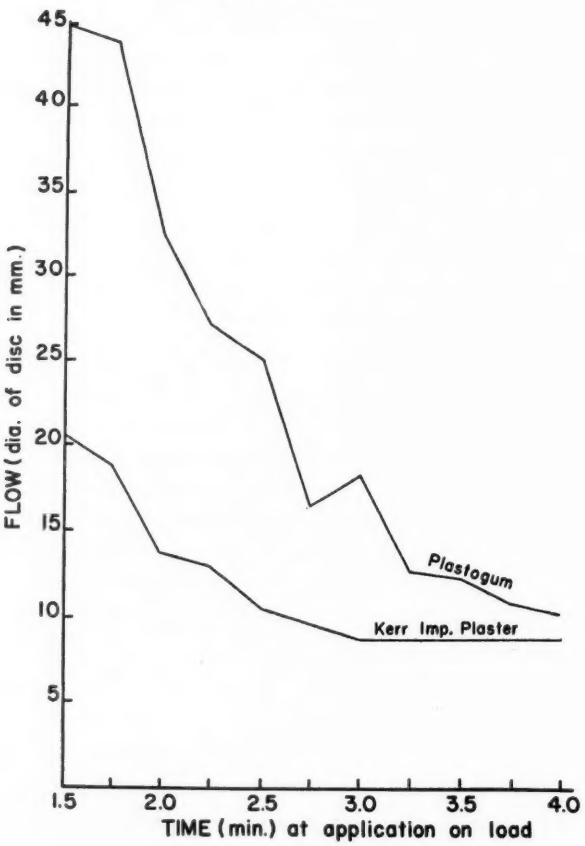

Fig. 5.—Flow of two plaster-type materials.

a definite relationship between flow and setting time for the zinc oxide-eugenol pastes. Although generally setting time and the time interval between initial and final set do indicate the flow which will be present at the time the tray is carried to the mouth, misleading conclusions might be drawn for a particular product if only the setting time is examined. There is need for further study in this direction.

TABLE II

	INITIAL SET	FINAL SET
Zinc Oxide-Eugenol Pastes		
1. Coe-Flo	6′30″	7′30″
2. Coe-All-Tec	5′00″	6′30″
3. S. S. White	3′00″	5′30″
4. Coe-Trans	2′15″	4′30″
5. Ackrapaste	2′00″	3′00″
6. Luralite	3′15″	4′00″
7. Truplastic	2′15″	2′45″
Alginates		
1. Jeltrate	2′15″	3′15″
2. Coe-Alginate	3′15″	4′45″
3. D-P	2′30″	3′30″
Rubber Base		
1. Permlastic	4′45″	6′15″
2. Getz-R28		
3. Coe-Flex	4′30″	7′15″
Plaster and Plastogum		
1. Plastogum	2′00″	4′15″
2. Kerr's Impression Plaster	2′15″	3′30″

DISCUSSION

The exact degree of flow most desirable for making secondary impressions is one of the more controversial subjects in the field of prosthetic dentistry. Some operators prefer a thin impression material, believing that this will reduce or eliminate soft tissue displacement. Others prefer a stiffer material and argue that the thin mix is more difficult to contain in the tray, will tend to incorporate air in the form of bubbles, and will produce inferior surface detail. No attempt has been made in this study to determine the "correct" amount of flow, and it is recognized that the flow characteristics for a given material will vary as batch formulas are altered. The study was designed merely to establish the effect upon flow by delayed insertion into the oral cavity and the relationship of flow and setting time of these various materials.

It was noted throughout the study that many of these materials varied considerably, both in setting time and flow, from tube to tube or even in different areas of the same tube.

SUMMARY

A study has been made of the degree of flow exhibited by 15 different impression materials commonly used in prosthetic dentistry and the amount of flow which

might be expected from these materials at various time intervals following the beginning of spatulation.

The research substantiates previous work where it has been found that the degree of flow varies from thin materials which exhibited almost unlimited flow, to those which were comparatively stiff. Some materials demonstrated a critical decrease in flow at room temperature, thus giving a limited amount of working time, while in other materials the flow remained high. Two of the seven zinc oxide-eugenol pastes, the alginates and the plaster-containing materials demonstrated this marked decrease in flow at certain time intervals. It is apparent then that if a specific flow is desirable, the time between mixing and insertion of the tray is critical for certain materials. The rubber base materials were not markedly influenced.

This marked reduction in flow, as exhibited by some of the materials, might be advantageous in reducing the possibility of distortion while the materials are setting in the mouth.

Although some materials showed a definite correlation between the flow and setting time, the reduction in flow could not always be predicted by examination of the setting time.

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TECHNIQUES WITH RUBBER BASE MATERIALS FOR INLAYS, CROWNS, AND FIXED BRIDGEWORK

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THE FAVORABLE CHARACTERISTICS inherent to the rubber base impression materials are comparable to those of the reversible and irreversible hydrocolloids.[1] The basic advantage these three materials have over those preceding them, such as modeling compound and wax, is that they are elastic within prescribed limits.[2] They will spring from undercut areas, and return to their original shape and dimensions, thus reproducing correct finishing lines on prepared teeth.

Sears' report in 1937 on the hydrocolloid impression technique was the cornerstone for the use of elastic materials in inlay and fixed bridgework.[3] Subsequently, Kimball,[4] Buchmann,[5] and Thompson,[6] confirmed his clinical findings. The scientific data on the truly elastic materials compiled by Paffenbarger,[7] James,[8] Phillips and Ito,[9] and Skinner,[10] gave a firm foundation to the empirical information obtained by clinicians.

During the past eighteen months, I have employed a white rubber base compound known commercially as "Thiokol." Chemically this substance is a mercaptan, requiring polymerization by a sulphur or peroxide activator. The following is a description of three impression techniques to be followed with this material. These methods have overcome many of the disadvantages of the alginate and hydrocolloid materials without sacrificing accuracy.

FOR INLAYS AND CROWNS

A loosely fitting band is festooned to the outline of the preparation with curved scissors, curved pliers, and a gold file (Fig. 1). Two holes are punched in the copper band with a hole punch pliers. One is made on the buccal and one on the lingual side of the band at the end opposite the festooning. These holes act as escapeways, and lock the impression material in the band. The end of the band which is not festooned is seared over with green stick compound which will act as a plunger. The rubber base material is mixed according to the manufacturer's instructions, and placed in the band with a plastic instrument. The tooth is dried, and some of the impression material is carried with an explorer or cement instrument to the inner recesses of the preparation to avoid trapping air. The band is

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now placed on the tooth, keeping the two escapeway holes covered with thumb and forefinger. When the band has been carried to place, the finger and thumb are taken off the holes. A little more pressure is exerted on the top of the band to cause some of the flowing rubber to extrude from the holes. The impression is held with one finger on the compound for at least one minute, without movement.

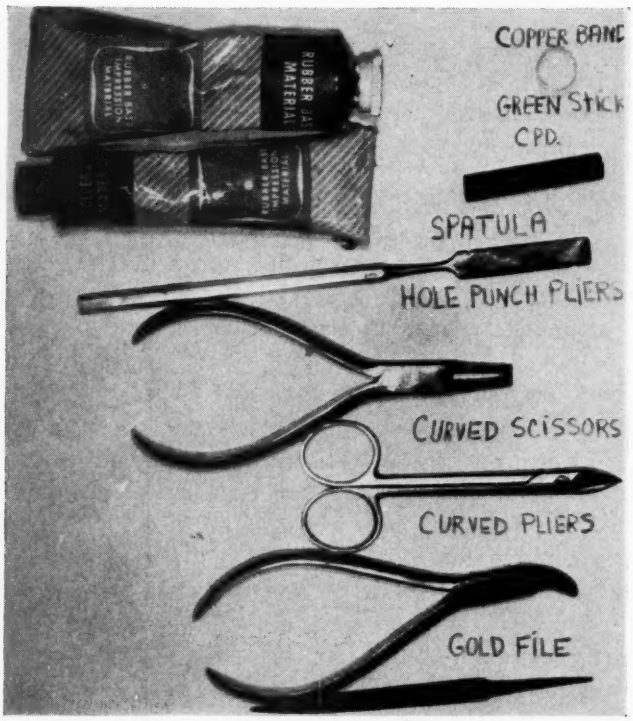

Fig. 1.—The armamentarium for rubber base impressions made in copper bands.

Fig. 2.—Twenty-gauge wax is placed on a study cast to prepare for making a Static X tray.

The impression must remain undisturbed on the tooth for three more minutes for a final set. The band is removed with one direct pull, without rocking. The die is then formed in the impression. It may be made of die stone or it may be silver-plated before the stone is poured into it.

BRIDGE IMPRESSION USING STATIC X TRAY AND RUBBER

Study casts are made from alginate impressions. The stone teeth in the quadrant involved are covered with 20 gauge wax (Fig. 2).

A perforated tray is chosen to fit the bridge area and approximating teeth, and both ends are walled off with utility wax. Static X is mixed and placed in the tray. Some of the flowing Static X is put on the top of the tray so that it will unite with the material inside the tray and thus lock it in place. It is imperative that elastic cement be placed on the inside of the tray and permitted to dry for five minutes before the rubber impression material is mixed and placed in it. The impression should be left in position undisturbed for five minutes before it is snapped off of the cast. The impression tray is now ready for the mouth (Fig. 3).

Fig. 3.—A tray prepared to receive the rubber impression material and be placed on the prepared area in the mouth.

Fig. 4.—An impression of the bridge area made with a rubber impression material.

After the abutment teeth have been prepared, the teeth are dried and a mix of rubber base impression material is placed inside the tray and over the teeth with an explorer or cement instrument. The tray is then set in place and kept there undisturbed for four minutes. The rubber-filled tray is then snapped off (Figs. 4 and 5), and is ready to be poured with die stone when convenient, within a period of a week. The rubber base materials bond themselves to the Static X chemically, and there is therefore no problem of adhesion of the impression to the tray.

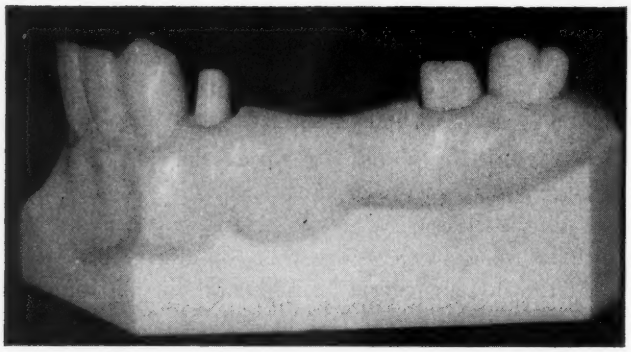

Fig. 5.—The prepared abutments on a model.

Fig. 6.—The teeth in the mouth prepared for a four-unit fixed bridge.

Fig. 7.

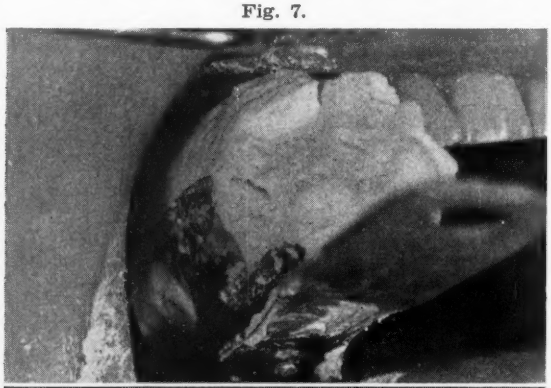

Fig. 8.

Fig. 7.—A tray filled with quick-setting plaster in place over rubber impressions in copper bands.
Fig. 8.—A combination rubber and plaster impression.

BRIDGE IMPRESSION USING PLASTER AND RUBBER IMPRESSION MATERIAL

Following the same procedure as for individual tooth impressions, festooned copper bands filled with the rubber impression material are placed on the dried veneer crown preparations, and permitted to set for four minutes (Fig. 6). A bridge tray, loaded with quick-setting impression plaster, is placed over the two band impressions and permitted to set (Fig. 7). The combination impression is then removed with one straight pull (Fig. 8). The impression is filled with Duroc to form the cast (Figs. 9 and 10). The hydrocolloid die technique can be used for this. A complete bridge can be fabricated and tried in the mouth at the patient's second visit (Fig. 11).

Fig. 9.

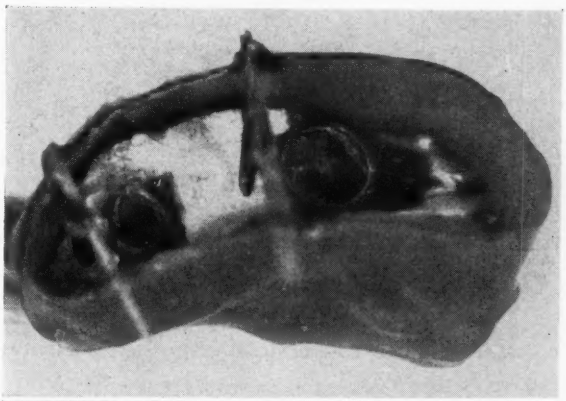

Fig. 10.

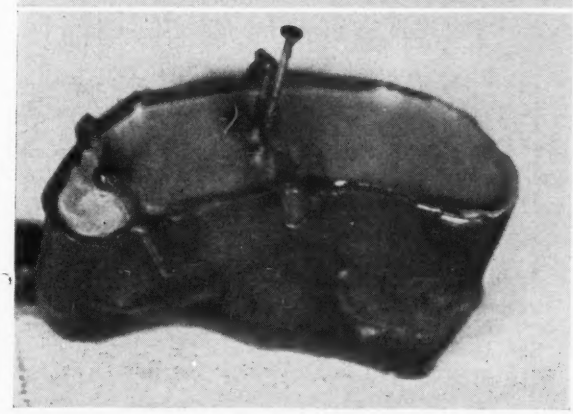

Fig. 9.—The impression boxed for pouring the cast and dies.
Fig. 10.—Duroc poured into the impression.

The Plaster-Rubber combination technique is simpler to use than the Static X-Rubber technique, since it eliminates the laboratory procedure of making a rubber base tray on a study cast. This technique is used routinely except where there are two approximating prepared teeth. Copper bands cannot always be seated correctly on two adjacent teeth.

ADVANTAGES OF RUBBER IMPRESSION MATERIALS

1. Dies can be formed in rubber impressions any time within seven days. Alginate and hydrocolloid impressions must be poured within one-half hour after their removal from the mouth.

2. Gum retraction is not a problem with rubber base impressions, since the material has "body" in the plastic state.

Fig. 11.—The completed bridge in the mouth.

3. The stone dies formed in rubber base impressions are uniformly smoother than those made in hydrocolloids.

4. Second casts or dies may be made in rubber base impressions.

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15 Canterbury Rd.
Great Neck, L.I., N.Y

THE INFLUENCE OF OVERLAPPING ELECTRICAL FIELDS ON THE INTERPRETATION OF ELECTROMYOGRAMS

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College of Dentistry, Ohio State University, Columbus, Ohio.

WHILE EXPLORING VARIOUS AREAS of the face with surface electrodes during routine electromyographic work, we became puzzled with some of our results. It did not seem logical that during clenching of the teeth, potential should be recorded in significant amounts from the forehead, ear lobe, and the tip of the nose. Also, during an uncontrolled opening movement of the mandible, the ear lobes and the mid-masseter muscle areas seemed to show far more electrical activity than one would expect.

From these observations, it became apparent that these recordings could be overlapping electrical fields from muscles not directly underlying the electrodes. If this assumption should be fact, incorrect interpretation of electromyograms might result. This study was undertaken to test that possibility.

METHODS AND PROCEDURES

The records were made using a Grass Model III-D electroencephalograph on the electromyograph settings. This instrument has eight recording channels, and permanent records are made by means of pen writers on regulated moving paper. A paper speed of 6 cm. per second was used. Instrument calibrations were such that an input signal of 50 microvolts produced a 6 mm. deflection of each pen.

Records were made with surface electrodes from many positions overlying the masseter, the temporal, and the digastric muscles. Other areas checked for electrical activity with surface electrodes were the forehead, the ear lobes, and the tip of the nose. Needle electrodes were also used for recordings from various parts of the masseter, temporal, and external pterygoid muscles. An intraoral needle electrode was inserted in the external pterygoid near its origin; simultaneously, an extra oral needle electrode was placed in the external pterygoid near its insertion. Both the needle electrodes and the attachment of the surface electrodes have been described by Moyers.[1] The irregularity of basic wave form shown on the electromyograms (Figs. 3, 4, 5, and 6) coming from the intraoral needle electrode in the external pterygoid muscles is thought to be due to movement of the exposed end of

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the curved needle, and the wire lead to this electrode. The interelectrode resistance was never above 18,000 ohms and in most instances varied between 8,000 and 10,000 ohms.

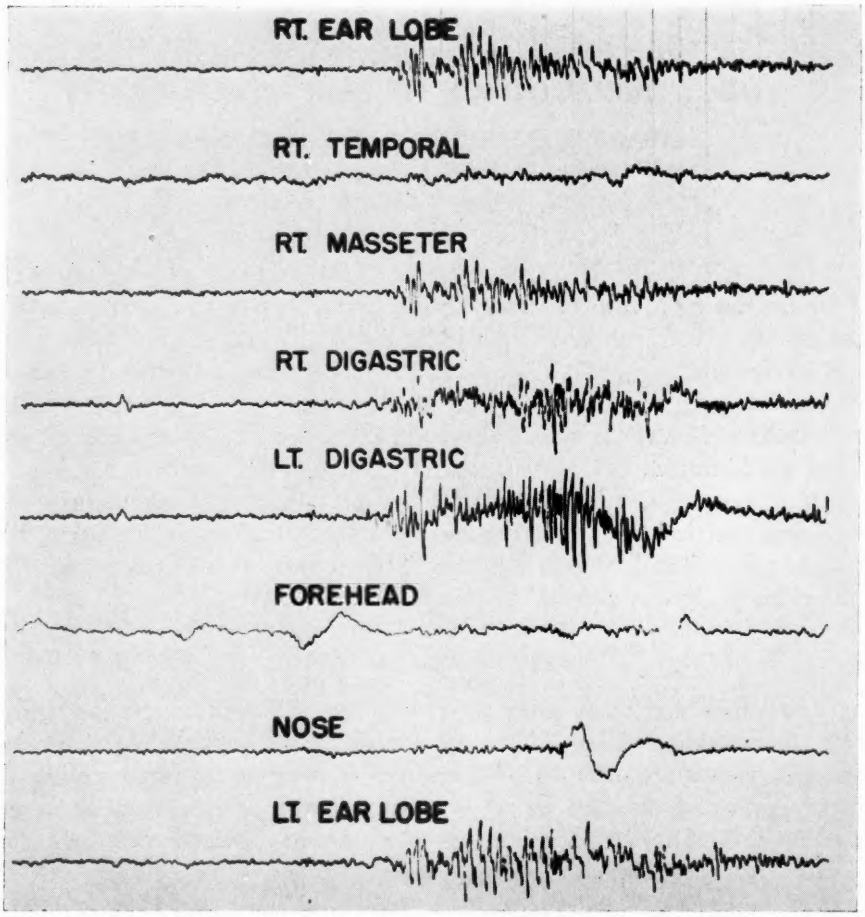

Fig. 1.—Electromyogram of uncontrolled opening. The increased electrical activity from the ear lobes, the masseter muscle, and the digastric muscles is quite apparent. Note the similarity of wave forms from the right ear lobe and the mid-portion of the masseter muscle.

This report is based on 24 separate investigations of 10 individuals which included many different jaw movements. These jaw movements include: protrusion, retrusion, uncontrolled opening, opening on the hinge axis, opening slightly from rest position, closing slightly from rest position, closing into occlusion, clenching the teeth, lateral excursions of the mandible, and normal chewing. Subjects were seated in a comfortable, upright position in an arm chair and were instructed to close their eyes while executing the various mandibular excursions.

RESULTS

During uncontrolled opening movements of the mandible, increased activity was noted primarily from the external pterygoid, digastric, and masseter muscle

areas, as well as from the ear lobes. A striking similarity of wave form is seen in most instances on the records from these same areas during this movement (Figs. 1 and 3).

However, during a so-called hinge axis mandibular opening, or retruded opening, activity was noted primarily from the digastric muscles. There was almost complete lack of increased activity from the external pterygoid, masseter, and temporal muscles, *and the ear lobes* during this movement (Figs. 2 and 4). The authors served as subjects for this learned movement.

When the mandible was moved to the left, the right external pterygoid muscle, the right ear lobe, and the right mid-masseter muscle recordings apparently showed the most increase in electrical activity (Fig. 5). Contrast with this (Fig. 6) the almost static or rest pattern on the electromyogram from these three same areas for a right mandibular excursion.

Clenching of the teeth showed electrical activity to be spread to all areas of the face, including the nose and particularly the forehead (Fig. 7). Needle electrodes in the external pterygoid muscles also picked up considerable increased activity in clenching (Table I).

TABLE I

RELATIVE AMOUNT OF INCREASED ACTIVITY OBSERVED ON THE FOLLOWING MANDIBULAR EXCURSIONS

	TYPE OF MOVEMENT						
LOCATION AND TYPE OF ELECTRODE	REST	CLENCH	OPEN WIDE	OPEN HINGE	PRO-TRUDE	LEFT LATERAL	RIGHT LATERAL
Right external pterygoid needle—extraoral	+	+++	++++	+	++++	++++	+
Right external pterygoid needle—intraoral	+	+++	++++	+	++++	++++	+
Left ear	+	++++	+++	+	+++	+	+++
Right ear	+	++++	+++	+	+++	+++	+
Left masseter middle needle electrode	+	++++	+++	+	+++	+	+++
Left masseter lower border needle	+	++++	++	+	++	+	++
Left masseter middle surface	+	++++	+++	+	+++	+	+++
Left masseter lower border surface	+	++++	++	+	++	+	++
Right digastric	+	+++	++++	++++	++	++	++
Left digastric	+	+++	++++	++++	++	++	++
Temporalis	+	++++	+	+	+	+	+
Nose	+	++	+	+	+	+	+
Forehead	+	+++	+	+	+	+	+

For purposes of analysis, it was necessary to classify the amount of activity recorded on the electromyograms for the various movements and the areas tested. The activity evident with the muscles at rest was used as a base reference and

classified as "minimum." The activity as recorded when the teeth were clenched was used as the "intense" electrical activity. "Slight" and "moderate" were arbitrary intermediates between these extremes (Fig. 8).

DISCUSSION

The ear lobe has been used by investigators[2, 3] as a reference point for other recording areas because it had been considered to be electrically inactive. However, a great amount of electrical activity is recorded from this area during both normal opening and forced closing jaw movements (Figs. 1, 3, and 7). Since it is quite obvious that there are no mandibular elevators or depressors in the ear

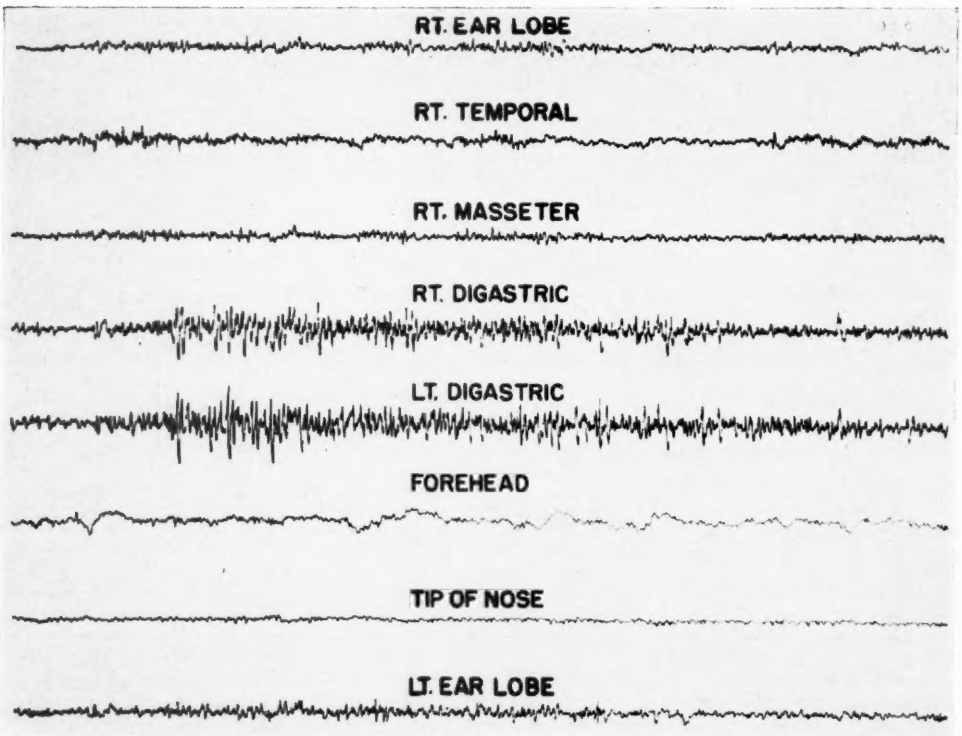

Fig. 2.—Hinge opening on same subject as in Fig. 1. The electrode positions are unchanged. There is practically no increased electrical activity from either ear lobe or the masseter muscle. This is in contrast with increased activity in the same areas. Compare with Fig. 1.

lobe, the potential must be arising from some other sources. The external pterygoid muscle, on opening, and the temporalis and masseter muscles, on closing, are obviously involved in these jaw movements. The external pterygoid and digastric muscles are the prime movers of the mandible in an uncontrolled opening.[4] The former muscle could be the source of the electrical activity during this movement, for when a hinge opening is made and the external pterygoid is not active (Fig. 4), the electrical potential recorded from the ear lobe is at a minimum (Figs. 2 and 4).

If potential can be recorded in reasonably large quantities from the ear lobes, it is undoubtedly extending to many other areas. Similar activity, presumably

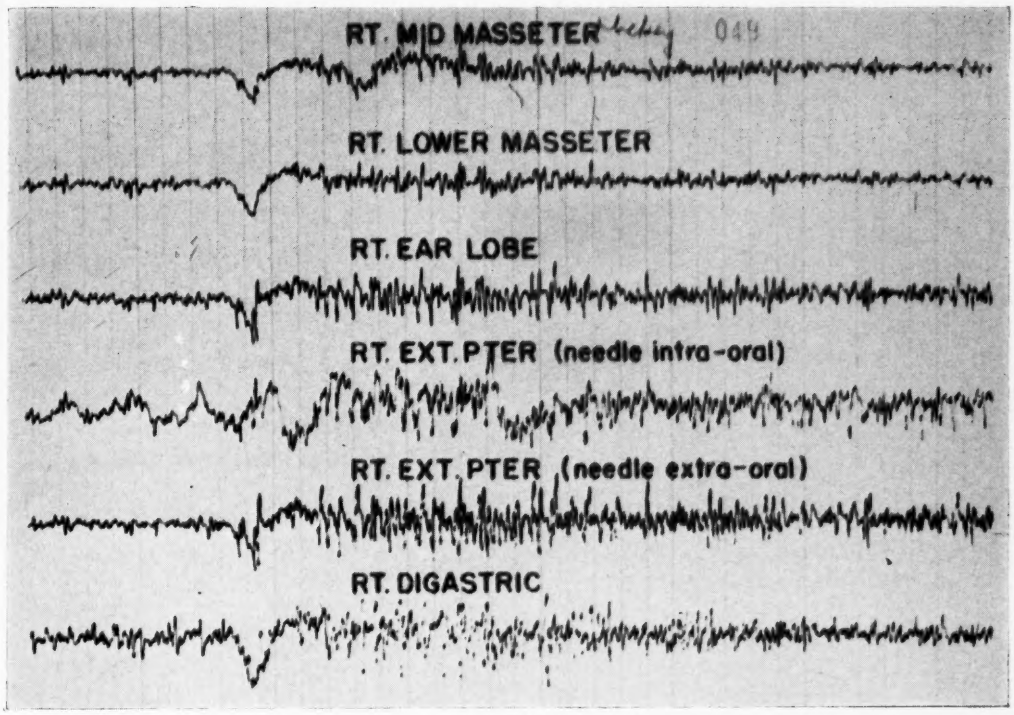

Fig. 3.—Uncontrolled opening. Note the increased activity in all areas. Compare the striking similarity of wave form between the mid-portion of the right masseter, the right ear lobe, and the right external pterygoid muscle (extraoral electrode).

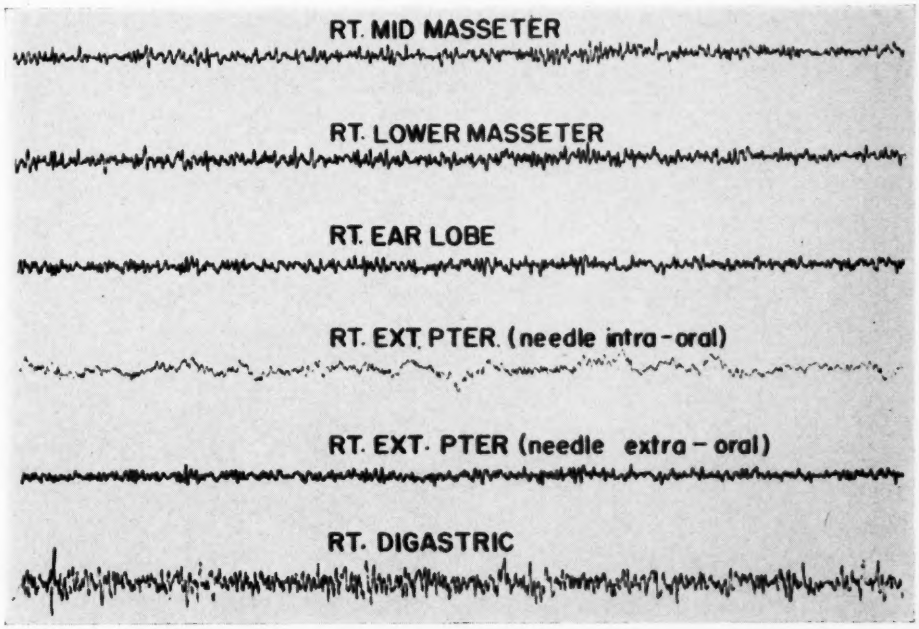

Fig. 4.—Hinge opening on same subject as in Fig. 3. The electrode positions are unchanged. There is no significant increase of activity from any area other than the right digastric muscle. Contrast this with the amount of increased activity from these areas on Fig. 3.

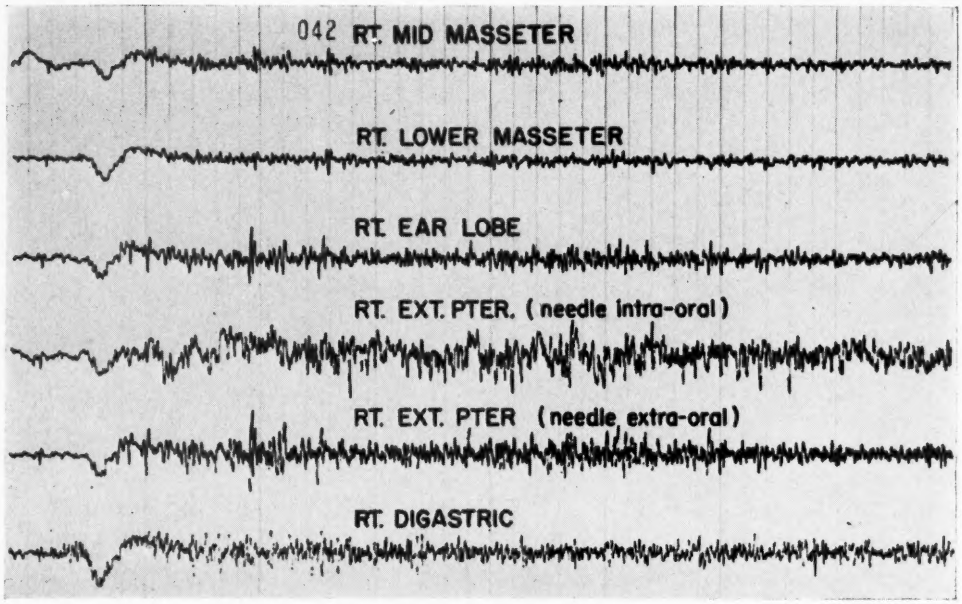

Fig. 5.—Left lateral excursion of the mandible. Note the increased activity chiefly from the right external pterygoid muscle areas, the right ear lobe, and the mid-portion of the right masseter muscle. Similarity of wave form is evident between the external pterygoid (extraoral needle), the right ear lobe, and the mid-portion of the right masseter muscle. The electrode positions are the same as Figs. 3 and 4.

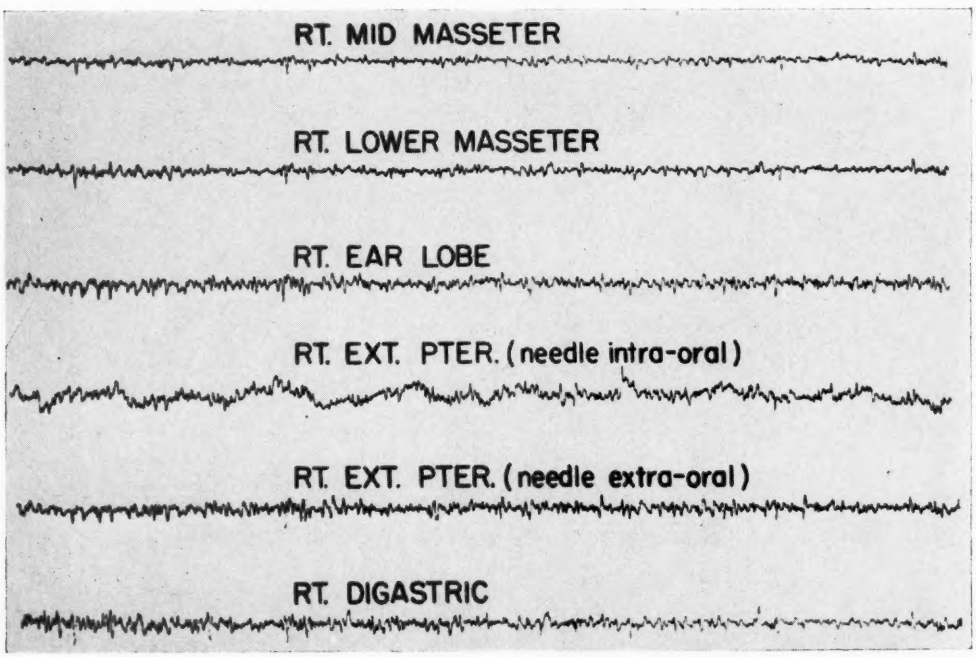

Fig. 6.—Right lateral excursion of the mandible. No significant increase of electrical activity is evident from any of these areas on the right side for this movement. Contrast this with the increases noted in Fig. 5. The electrode positions are the same as Figs. 3, 4, and 5.

from the external pterygoid muscle, is registered during uncontrolled opening movements to varying degrees from electrodes from the masseter muscle (Figs. 1 and 3). This electrical activity is very slight during the hinge opening. This leads us to believe its true source is the external pterygoid muscle. (Figs. 2

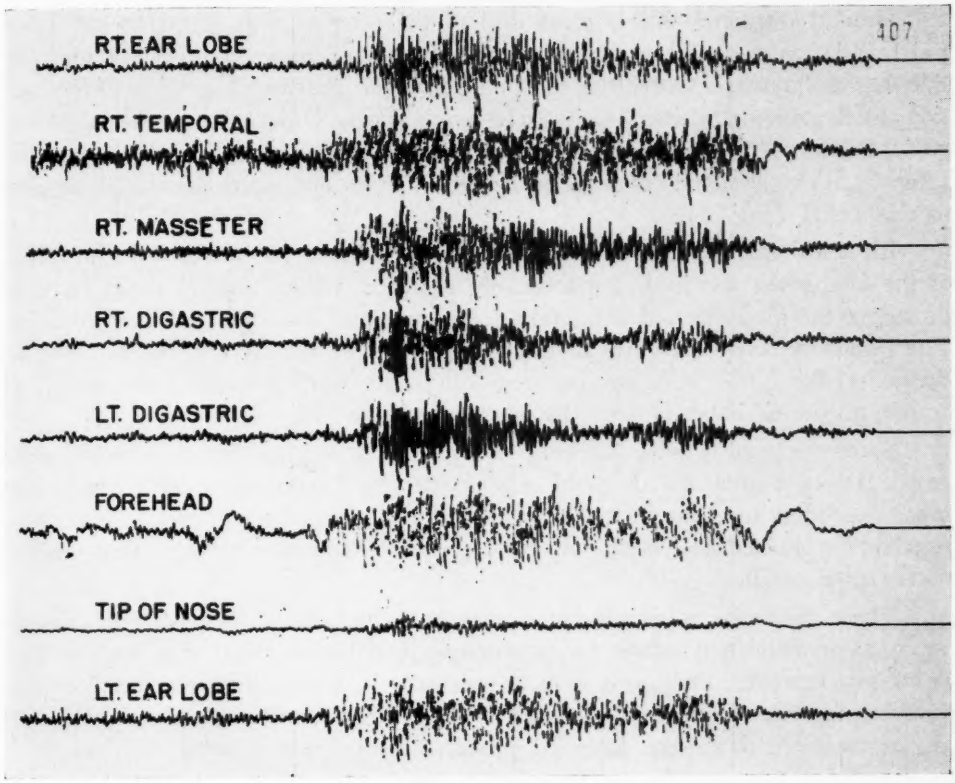

Fig. 7.—Clenching of the teeth. Increased electrical activity eminates from all areas. Note the amount of activity recorded from both ear lobes, the forehead, the digastric muscles, and the moderate increases recorded from the tip of the nose. The greatest amount of this activity is thought to be overlapping electrical output from adjacent areas.

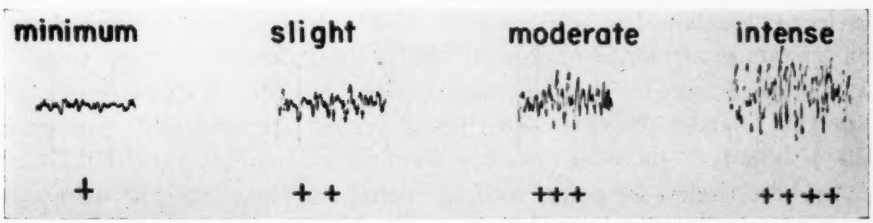

Fig. 8.—The arbitrary classification of electrical activity as recorded upon the electromyogram for purposes of gross analysis (see Table 1).

and 4). It is worthy of note that the waves of electrical activity recorded from the areas of the external pterygoid muscles, ear lobe, and masseter muscle show extreme similarity in form and frequency during the uncontrolled opening movements (Figs. 1 and 3). This again tends to indicate it has a common source.

It is possible that the activity seen in the opening movement from the masseter area could be totally the result of a stabilizing or holding action of this muscle. However, this activity ceases when the external pterygoid is inactive in the hinge opening. Therefore, we feel that it is electrical activity from the external pterygoid muscle that was recorded from the masseter muscle during this movement.

Similarly, we feel that a great deal of the activity seen from the ear lobes and middle masseter areas, during mandibular lateral excursions to the opposite side, has as its actual source the external pterygoid muscles (Fig. 5). On excursions to the side on which the electrodes were attached (when the external pterygoid of that side is not contracting) increased electrical activity is not observed (Fig. 6). The similarity of wave form from the various active areas add support to this belief (Fig. 5).

Electrical activity can be recorded almost without exception from any area of the face when the teeth are forcefully clenched. This activity could have as its source the masseter and temporalis rather than the external pterygoid muscles. The similarity between the tracings from the masseter muscle and the ear lobe on the same side is the basis for our reasoning that, during closing, the spread of activity to the ear lobes is from the masseter muscle (Fig. 7).

Since electrical activity has been shown to exist in these areas, it would seem reasonable to assume that it could exist to varying degrees in most all recording areas depending upon the extent of jaw movements and force applied. Therefore, overlapping of electrical fields will have to be considered in interpreting electromyographic results.

These observations should not in any way affect the validity of electromyography as an important source for physiologic information about muscles. It does point out, however, that great care is necessary in interpreting electromyograms. Overlapping electrical fields must be taken into consideration when assigning particular functions to muscles as based on electromyographic records.

CONCLUSIONS

1. Electrical activity thought to be originating from certain muscles or areas may actually be overlapping electrical fields from other muscles. This overlapping electrical activity has been recorded with both needle and surface electrodes, and it appears to be more intense with surface electrodes.

2. A great amount of the electrical activity recorded from the region of the mid-portion of the masseter muscle, during regular (uncontrolled) jaw openings or lateral excursions, is thought to arise from the external pterygoid muscle.

3. Certain reference points used in electromyography, such as the ear lobes, are not necessarily electrically inactive.

4. This overlapping of electrical activity may cause erroneous conclusions in electromyographic interpretation.

5. The usefulness of electromyography for studying the action of muscles is not questioned, provided the overlapping of fields of electrical activity is recognized and considered in the interpretation of electromyograms.

ACKNOWLEDGMENT

We wish to thank Dr. Morgan L. Allison, Chairman, Division of Oral Surgery, College of Dentistry, Ohio State University, for inserting needle electrodes into the external pterygoid muscles.

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PULPAL EFFECTS OF OPERATIVE DENTISTRY*

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THE INTRODUCTION OF NEWER methods of cavity preparation has stimulated studies of the effects of cavity preparation on the dental pulp. The airbrasive technique, the ultrasonic technique, and techniques using the rotary instrument at increasingly higher speeds should all be thoroughly investigated for their effects on living tissue as well as for their efficiency in the treatment of dental diseases. Since the effects on the dental pulp of these various techniques are already being studied at several centers, it was deemed advisable to invite representative investigators to the Ohio State University for a conference on tissue reactions to cavity preparation.

Those actively participating in this conference, held May 21, 1956, included Dr. M. M. Ash of the University of Michigan, Dr. Paul E. Boyle of the University of Pennsylvania, Dr. Robert Colby of the U. S. Naval Dental School, Bethesda, Dr. William Lefkowitz of the Ohio State University, Dr. David Mitchell of Indiana University, Dr. Arne Nielsen of the U. S. Naval Dental School, Bethesda, Dr. Harry Postle of the Ohio State University, Dr. Hamilton Robinson of the Ohio State University, Dr. H. R. Stanley of the National Institute of Dental Health, Dr. Grant Van Huysen of Indiana University, Dr. Leo Zach of New York University, and Dr. Helmut Zander of the University of Minnesota.

Dr. Lewis Balmuth of the Cavitron Corporation was invited to serve as a consultant on physical aspects of ultrasonics.

During the one day conference, the results of studies conducted by the participants at Indiana University, the U. S. Naval Dental School, the National Institute of Dental Research, New York University, the University of Minnesota, and the Ohio State University were presented and reviewed. Representative slides from the participants' studies were compared microscopically. The following conclusions were drawn:

1. The pulp is remarkably resistant, rather than being a delicate organ. The ability of the pulp to tolerate injuries within reasonable limits is important to the dentist and patient, but should not be abused.
2. Many of the so-called degenerative changes in the pulp, heretofore described, may have been artifacts produced in preparation of microscopic specimens.

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*A Report of the Ohio State University Conference on Tissue Reactions to Operative Procedures.

**Compiled for and cosigned by the participants listed at the end of this report.

3. The only irreparable injuries to the pulps of teeth of limited growth, such as the teeth of dogs, monkeys, and human subjects under the conditions of experiments performed by the participants, were on human teeth subjected to cavity preparation by high speed rotating instruments without the use of a water coolant. Cavity preparations by high speed rotating instruments using a water coolant, by ultrasonic techniques, and by airbrasive techniques produced no significant lesions of the pulps in teeth of dogs, monkeys, and human subjects.
4. In teeth of continuous eruption (incisor of guinea pigs), injuries were observed in the forming dentin which had been at the root end at the time of cavity preparations by ultrasonics.
5. There is no evidence to suggest that either the airbrasive technique, the high speed rotary technique used with water coolants, or the ultrasonic technique is injurious to the pulps of fully formed teeth.
6. The effect of the new techniques on the apical root dentin of developing teeth should be investigated.

M. M. Ash, D.D.S., University of Michigan
Paul E. Boyle, D.M.D., Western Reserve University
William Lefkowitz, D.D.S., Ohio State University
David Mitchell, D.D.S., Ph.D., Indiana University
Harry H. Postle, D.D.S., Ohio State University
Hamilton Robinson, D.D.S., Ohio State University
Grant Van Huysen, D.D.S., Indiana University
Leo Zach, D.D.S., New York University
Helmut Zander, D.D.S., M.S., University of Minnesota

Ohio State University
College of Dentistry
Columbus 10, Ohio

FIFTH ANNUAL ESSAY CONTEST

Sponsored by

THE AMERICAN DENTURE SOCIETY

PRIZES WILL BE AWARDED to the two senior dental students who submit the best essays on prosthetic dentistry in the fifth annual essay contest sponsored by The American Denture Society. The purpose of the contest is to stimulate technical writing by dental students.

The first prize is Five Hundred Dollars ($500.00) and the second prize is Three Hundred Dollars ($300.00).

RULES

1. The contest is open to all senior dental students in the dental colleges of the United States and Canada.
2. Only two essays may be submitted from any one dental college. (It is recommended that each dental college conduct its own contest to determine the two best essays submitted by members of its senior class.)
3. All essays submitted in the contest shall be accompanied by a letter from the professor of prosthetic dentistry and/or the dean of the dental college from which they originate. This provision is to assure the authenticity of all essays entered in the contest.
4. Essays must be postmarked on or before July 15, 1957. It is recommended that students start preparing their essays by the middle of their junior year and complete them by the middle of their senior year.
5. Essays are to be on some phase of prosthetic dentistry, and limited to a maximum of 2,500 words.
6. Essays must be worthy of publication in the JOURNAL OF PROSTHETIC DENTISTRY.
7. Essays must be typewritten, double spaced, on a good grade of white bond paper 8½ by 11 inches. No carbon copies or essays on onion skin paper will be considered. Paragraphs must be indicated clearly by indentations, and generous margins must be allowed on each page.
8. Illustrations must conform to the standards of the JOURNAL OF PROSTHETIC DENTISTRY, if they are used. Only good glossy black and white photographic prints or drawings in India ink may be used. Each illustration should be mounted on a separate sheet of paper with the figure number and the legend typed on the paper beneath the illustration.

9. References must conform to the style used in the JOURNAL OF PROSTHETIC DENTISTRY.

10. Essays are to become the property of The American Denture Society. None will be returned.

11. The judges of the contest are members of a committee of The American Denture Society. The decision of the judges is final.

12. Essays are to be clearly marked "Contest Essay" and sent, with a letter from the professor of prosthetic dentistry or the dean of the dental college indicating that this essay is an official entry from the dental college, to:

Dr. Victor L. Steffel

Secretary, American Denture Society
College of Dentistry, Ohio State University,
Columbus 10, Ohio

News and Notes

MEETINGS

Academy of Denture Prosthetics, Deshler-Hilton Hotel, Columbus, Ohio, April 28 to May 4, 1957.

American Association for Cleft Palate Rehabilitation, Hotel Cleveland, Cleveland, Ohio, May 2 to 4, 1957.

For further information, write to McKenzie W. Buck, Speech and Hearing Clinic, University of Florida, Gainesville, Fla.

The Canadian Dental Convention, Winnipeg, Manitoba, June 23 to 26, 1957.

For further information, write to Dr. F. W. Jones, 904 Boyd Building, Winnipeg, Manitoba, Canada.

Tenth Triennial Pacific Coast Dental Conference, San Diego, Calif., Aug. 19 to 22, 1957.

Inquiries and requests for reservations may be addressed to Dr. C. W. Gilman, Secretary, 219 East 8th St., National City, Calif.

Fifteenth Australian Dental Congress, Adelaide, South Australia, Feb. 23 to 27, 1959.

For further information, write to the Secretary, 15th Australian Dental Congress, 51 Grenfell St., Adelaide, South Australia.

ANNOUNCEMENTS

Columbia University, School of Dental and Oral Surgery announces a course on the Management of Temporomandibular Joint Disorders, given by Dr. Laszlo Schwartz and associates, May 1 to 3, 1957. For further information write to the Division of Clinical Oral Physiology, Columbia University School of Dental and Oral Surgery, 630 West 168th St., New York 32, N. Y.

The University of Alabama, School of Dentistry, announces the following refresher courses:

Oral Roentgenology, Dr. Arthur H. Wuehrmann, April 6-8, 1957.
Partial Denture Prosthesis, Dr. Oliver C. Applegate, April 11-13, 1957.
Emergency Care in the Dental Office, Dr. Emanuel Cheraskin, May 4-6, 1957.
Practical Root Canal Therapy, Dr. Adeeb E. Thomas, May 11-13, 1957.

For further information write to Refresher Course Program, University of Alabama, School of Dentistry, 1919—7th Ave., S., Birmingham 3, Ala.

The Medical College of Virginia, School of Dentistry, announces a series of postgraduate courses of interest to general practitioners. These courses are given by the members of the faculty.

Anatomy of the Head and Neck, March 18 to 22, 1957.

Oral Surgery, April 1 to 3, 1957.

Roentgenology, April 8 to 10, 1957.

For further information, write to H. T. Knighton, Director of Postgraduate and Graduate Instruction, Medical College of Virginia, School of Dentistry, Richmond 19, Va.

The University of Pennsylvania, School of Dentistry, announces the following postgraduate courses:

Complete Denture Prosthesis, Dr. Victor Lucia, March 18 to 23, 1957.

The Eighth Mid-Atlantic States Conference in Dentistry at Buck Hill Falls, Pa., Dr. Lester W. Burket, April 14 to 19, 1957.

Clinical Oral Pathology for the General Practitioner, Drs. D. Walter Cohen and Lionel Gold, Thursday evenings, March 7 to May 23, 1957.

Surgical Pathology, Dr. Lionel Gold, Tuesday evenings, March 5 to June 18, 1957.

For further information concerning these courses please communicate with Postgraduate Courses, University of Pennsylvania, School of Dentistry, 4001 Spruce St., Philadelphia 4, Pa.

Temple University School of Dentistry announces the following postgraduate course for the 1956-1957 session:

Orthodontics in Periodontal Therapy, Dr. Jack Alloy and Dr. Maxwell Fogelman, April 11-13, 1957.

For additional information and application, write to Dr. Louis Herman, Postgraduate Division, Temple University School of Dentistry, 3223 North Broad St., Philadelphia 40, Pa.

The University of Santo Domingo College of Dentistry announces three courses to be given in conjunction with the University of Alabama School of Dentistry. These three programs will be held in Ciudad Trujillo, Dominican Republic.

Pedodontics, Dr. Sidney B. Finn, Sept. 9-13, 1957.

Operative Dentistry and Endodontics, Dr. A. E. Thomas, July 8-12, 1957.

Complete Dentures, Dr. Horacio Read Barreras, August 26-30, 1957.

For further details, contact Dr. Hector C. Franco Santoni, Dean, University of Santo Domingo College of Dentistry, Ciudad Trujillo, Dominican Republic.

The Ohio State University College of Dentistry announces the following postgraduate courses to be given during the 1956-1957 school year. The enrollment of each course is limited in order to permit intimate teaching.

Anatomy of the Head and Neck, Dr. Linden F. Edwards, March 18 to 22.
Oral Surgery, Dr. Morgan L. Allison and Staff, April 8 to 12.
Pedodontics, Drs. Lyle S. Pettit and B. H. Williams, May 6 to 10.
Review of Clinical Dentistry, Dental Faculty, May 13 to 17.

For further information and application, write to Postgraduate Division, College of Dentistry, Ohio State University, Columbus 10, Ohio.

The Veterans Administration Hospital, Iowa City, Iowa, in affiliation with the State University of Iowa, College of Dentistry, announces that two rotating dental internships and one residency in Prosthetics will be available for the year beginning July, 1957. Application material and information may be obtained from the Chief, Dental Service, VA Hospital, Iowa City, Iowa.

The Veterans Administration Medical Teaching Group Hospital of Memphis, Tennessee, announces that two rotating dental internships and one residency in Prosthodontia will be available for the year beginning July, 1957. Information and application forms may be obtained from the Chief of the Dental Service, Veterans Administration Medical Teaching Group Hospital, Memphis, Tennessee.

The Ohio State University College of Dentistry announces that it is receiving applications of students for the Curriculum of Dental Laboratory Technology. This course of study of the laboratory phases of prosthodontics extends over two academic years and leads to a Certificate of Graduate Dental Laboratory Technologist. For further information, write to the Chairman of Dental Laboratory Technology, Ohio State University College of Dentistry, Columbus 10, Ohio.